KAL EQUIP


# FOUR (4) GAS EMISSIONS ANALYZER MODEL 5000

MADE IN U.S.A.

2-209001

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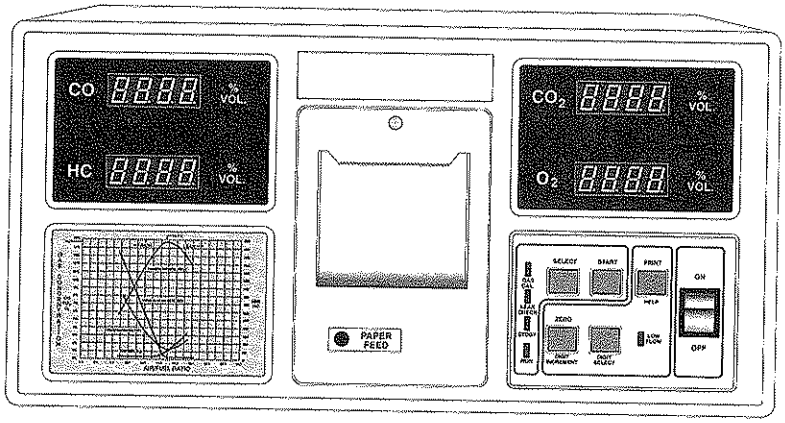
# TABLE OF CONTENTS

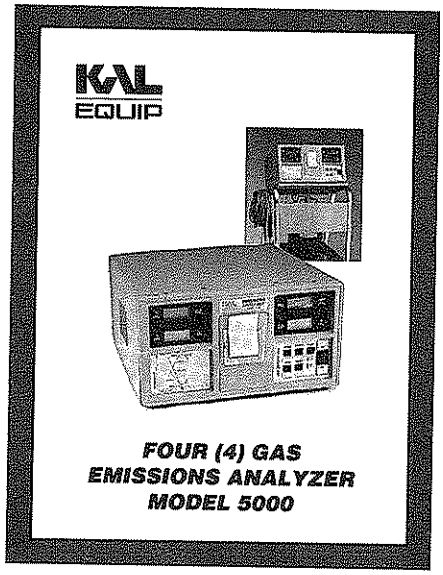
# PARTS LIST

## SECTION 1

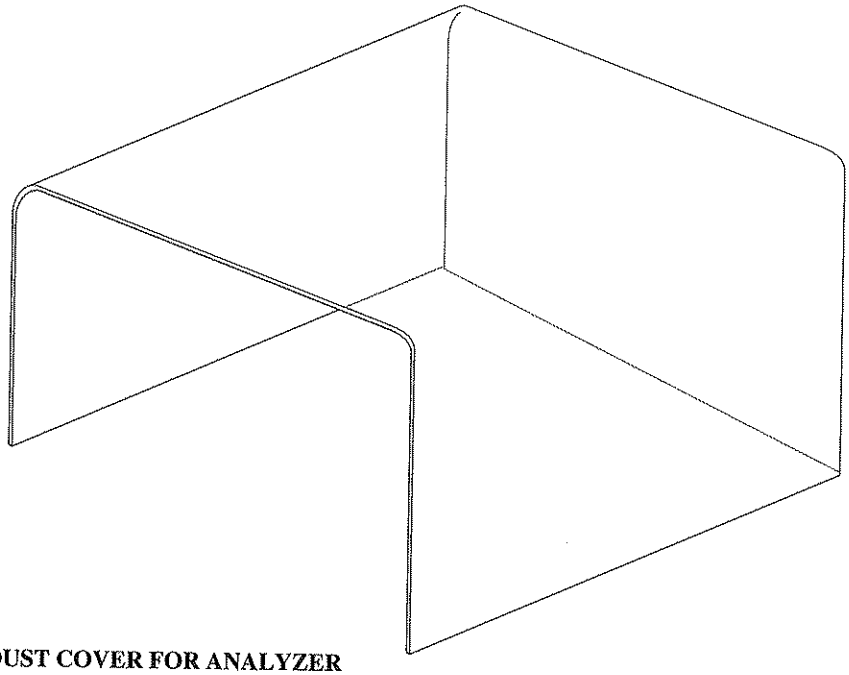
**THESE SEPARATE PARTS SHOULD BE INCLUDED WITH THE PURCHASE OF YOUR NEW FOUR GAS EMISSIONS ANALYZER.**



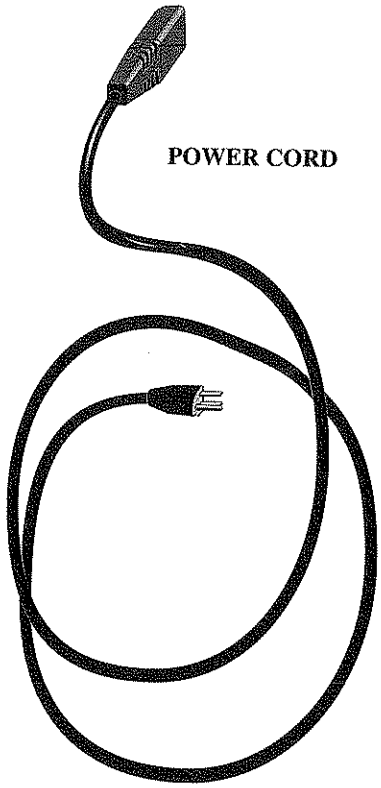

FOUR (4) GAS EMISSIONS ANALYZER




INSTRUCTION MANUAL



DUST COVER FOR ANALYZER

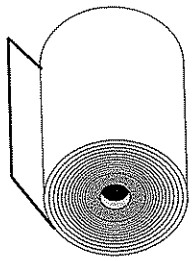


POWER CORD

# PARTS LIST

## SECTION 1

100 ft ROLL OF PRINTER PAPER

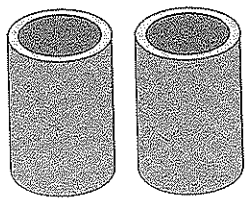


PRINTER PAPER AXLE ROD

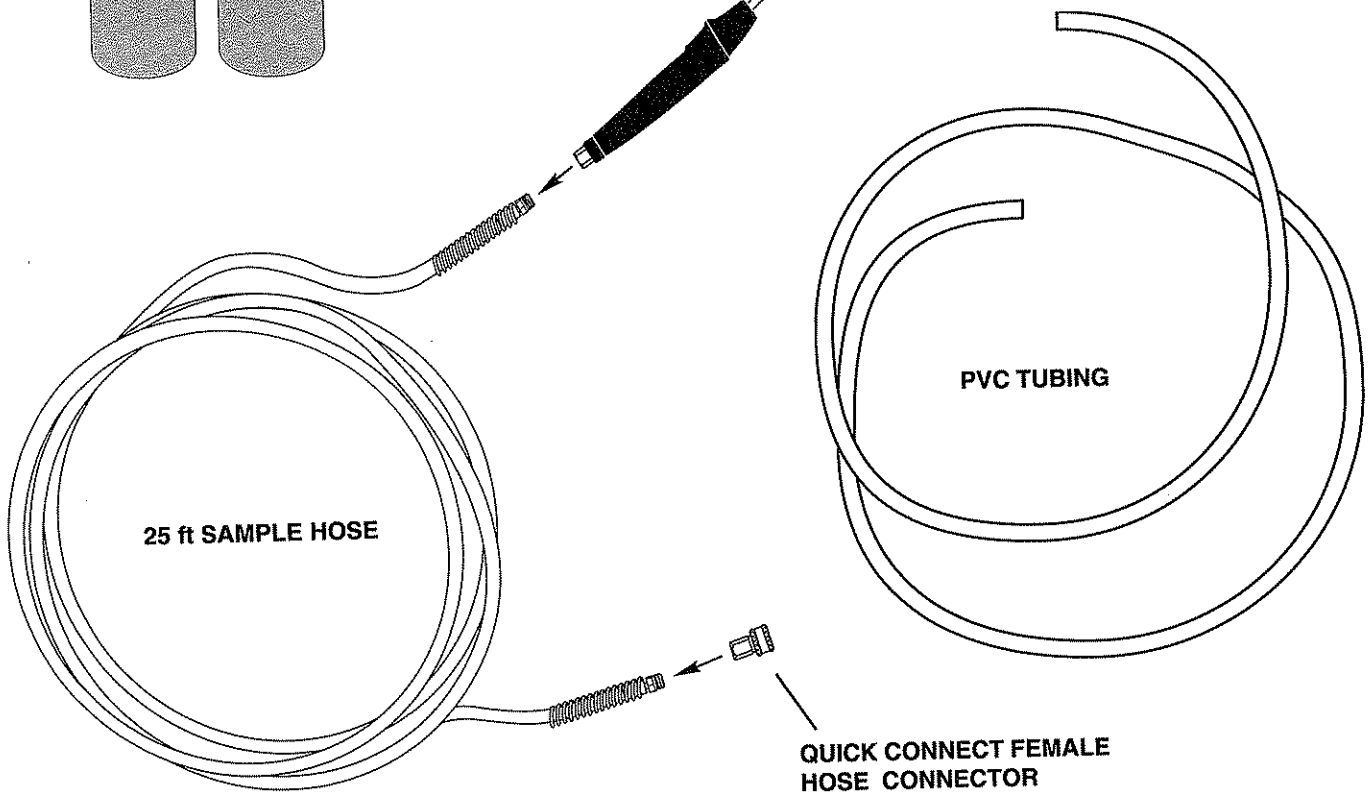
FLEXIBLE METAL HOSE

LEAK CHECK CAPS

TWO SPARE WHITE FILTERS FOR
THE TRI FILTER ASSEMBLY



SAMPLE HOSE HANDLE




QUICK CONNECT FEMALE
HOSE CONNECTOR

# VOLTAGE SELECTION

## SECTION 2

### IMPORTANT! AVOID ANALYZER DAMAGE, READ THIS FIRST!

This is a dual voltage analyzer. Before plugging it in for the first time, it is important to check that the voltage selector is in the position which matches the voltage available in your location, and that properly rated fuses are installed. Check these parameters as follows: (See FIGURE 1).

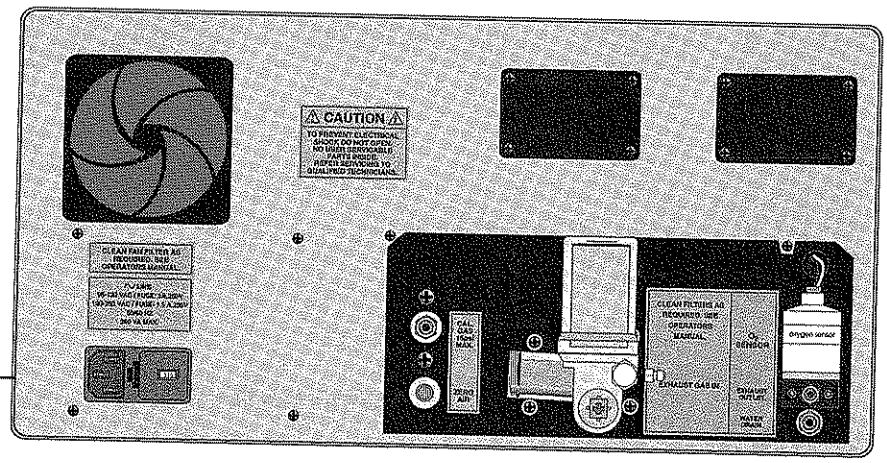



FIGURE 1:
**VOLTAGE SELECTOR LOCATION, ADJUSTMENT, AND FUSE LOCATION.**

**1.** The voltage selector and fuses are located in the lower left corner of the analyzer's rear panel. (See FIGURE 1).

**2.** Check the voltage indicator number in the center of the voltage selector cover/fuse holder. Compare it to the chart on next page, and to the voltage available in your location. If the voltage indicator number matches your requirement, no voltage changes will be made.

**3.** To gain fuse and voltage selector access, disconnect the power cord from the power input receptacle on the rear of the analyzer if it has been installed.

**4.** Using a small screwdriver, depress the voltage selector cover/ fuse holder locking latch (located directly adjacent to the power input receptacle see FIGURE 1a) to release it, and slide the cover out of the carrier. The fuses will come out with the cover. Check the rating on the fuses. They should match the chart on the next page. Replace them with the proper value if necessary. The fuses supplied with your analyzer have been sized to match the voltage selector setting and supplied A. C. power cord. If the voltage setting is changed, properly rated fuses will need to be obtained.

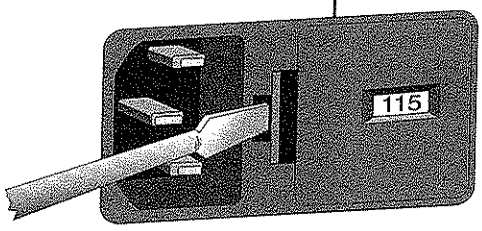



FIGURE 1a:
**Remove fuse holder and voltage selector using a small screwdriver.**

# FUSE LOCATION

## SECTION 3

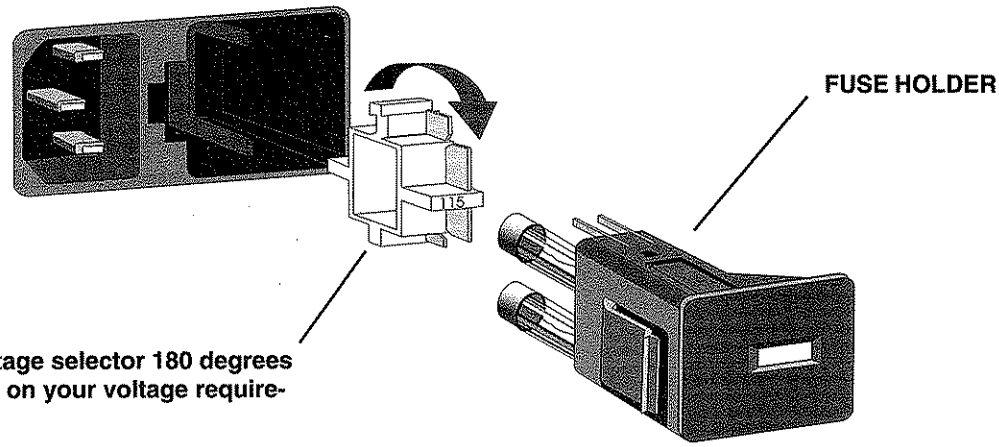



FIGURE 2:
**VOLTAGE SELECTOR, ADJUSTMENT, AND FUSE LOCATION.**

| INDICATOR | FUSE | VOLTAGE RANGE |
|---|---|---|
| 115 | 3.0 AMP | 95 - 130 VAC |
| 230 | 1.5 AMP | 190 - 250 VAC |

**5.** If the voltage selector needs to be changed proceed to the next step. Otherwise, reinstall the fuse cover containing the proper fuses and proceed to step 9.

**6.** Using a small screwdriver, remove the voltage selector from the carrier. The voltage selector is the piece with the 115 or 230 number stamped in it.

**7.** Rotate the voltage selector 1/2 turn, and reinsert it securely into the carrier (see FIGURE 2). When correctly inserted, the metal contacts will be located towards the center of the analyzer, furthest from the power input receptacle.

**8.** Reinsert the voltage selector cover/fuse holder into the carrier, pushing it in until it latches (snaps) into place.

**9.** Check that the voltage indicator number now matches your requirement. When it does, adjustment is complete.

**10.** Connect the power cord.

# INSTALLATION PROCEDURES

## SECTION 4

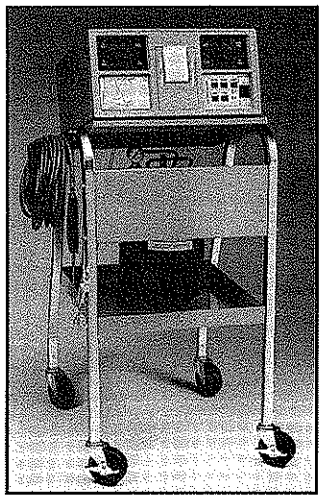


FIGURE 3:
**OPTIONAL STAND**

You have purchased a complex electronic instrument. Although designed and produced to withstand rugged use, observing the following recommendations on installation will help extend the life of your analyzer. As with any piece of electronic equipment, store it and use it in a weather controlled and protected environment.

**1.** An optional equipment stand such as the one shown in FIGURE 3 provides a sturdy, stable mounting surface, while at the same time providing good mobility. This figure illustrates the recommended mounting configurations. Consult your dealer or tool representative for more information on stands.

**2.** If your requirements preclude the use of a stand, select a sturdy, stable surface where the analyzer will be properly protected.

## REQUIRED INITIAL ASSEMBLY

The following simple assembly procedures are required before your analyzer is ready for use.

### PRINTER PAPER INSTALLATION

To ensure maximum protection of the analyzer during shipping, printer paper has not been installed. Follow the procedure outlined below to load the paper.

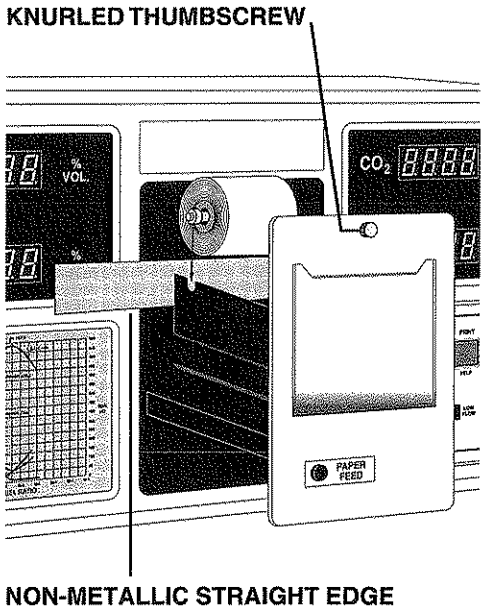



FIGURE 4:
**PRINTER DOOR ASSEMBLY**

**1.** With power to the analyzer **OFF**, loosen the knurled thumbscrew at the top of the printer door until it releases from the front panel of the analyzer. Pull the printer out the front of the analyzer until it stops (approximately 5 1/2"). The printer assembly can be propped open by placing a **non-metallic** straight edge between the rear of the printer assembly bracket and the front of the front panel as shown in FIGURE 4.

**2.** Turn power to the analyzer **ON**. (Note that the paper feed button will work immediately. It is not necessary to wait out the analyzer's warmup cycle.) Remove any remaining paper in the printer assembly by using the paper feed button, and/or gently pulling the paper out by hand from the front of the printer assembly in the area of the tear bar. **Do not attempt to pull the remaining paper out from the paper feed side (rear) of the unit. This may jam and/or damage the printer mechanism!** If necessary, the printer lens/tear bar may be removed from the printer door by gently squeezing the sides of the lens, and then pulling forward. When all paper has been removed from the printer mechanism, snap the printer lens/tear bar back into position.

**3.** Remove the empty roll and axle from the printer by lifting it straight up. (If this is the initial paper installation on a new analyzer, the paper roll axle and paper will be found in the accessory package).

# INSTALLATION PROCEDURES

## SECTION 4

**Be sure to insert paper between plastic bar and thin metal guide; NOT BEHIND THE METAL GUIDE.**

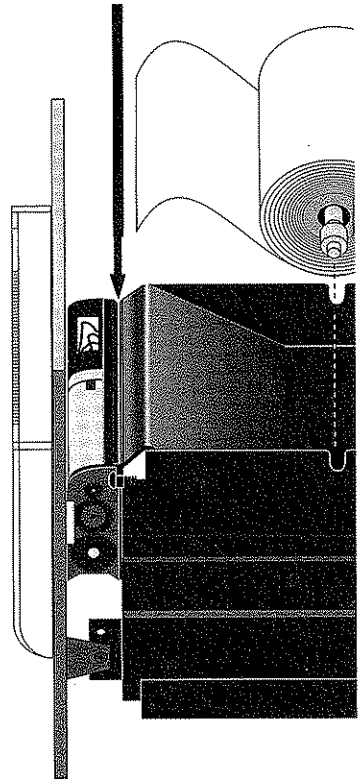


FIGURE 5:
**PRINTER PAPER INSTALLATION**

**4.** Make a 90 degree even cut across the leading edge of the new roll of paper.

**5.** Feed the paper straight down into the printer mechanism directly behind the plastic guide bar as shown in FIGURE 5. As illustrated, the paper must exit the roll from the bottom, not the top. Do not insert the paper behind the thin metal guide located directly behind the plastic guide bar. Gently feed the paper down as far as it will go by hand. When resistance is felt, continue to hold downward pressure on the paper while simultaneously pressing and holding the paper feed button. The printer mechanism should draw the paper in and feed it out the front slot in the printer door and up along the inside of the printer lens/tear bar. If the printer mechanism does not draw the paper in, or the mechanism sounds like it is laboring excessively, remove the paper, make a fresh cut in it, and repeat the feed process.

**6.** Turn the analyzer **OFF**.

**7.** Slide the printer back into the analyzer, and tighten the knurled thumbscrew.

## DRAIN HOSE INSTALLATION

Your analyzer is supplied with approximately three (3) feet of drain hose. This hose will be found in the accessory package. Additional hose is available if required. See the **REPLACEMENT PARTS** section of this manual.

**1.** Push one end of the hose onto the barbed **WATER DRAIN** fitting located in the lower right corner of the rear panel of the analyzer. See FIGURE 6.

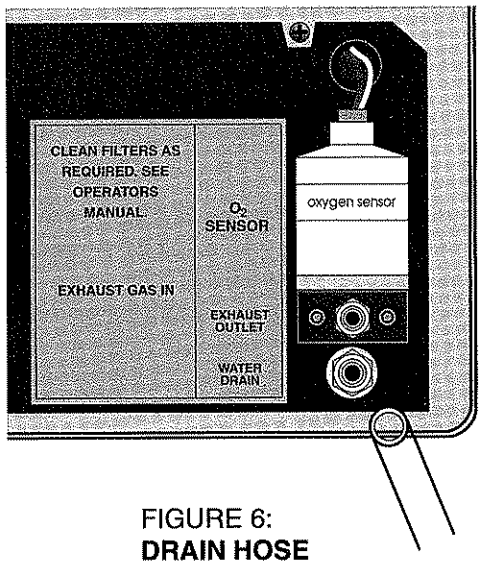



FIGURE 6:
**DRAIN HOSE INSTALLATION**

**CAUTION**

Do not route the drain hose in such a way that it could become crushed or kinked (by an equipment stand caster for example). If the drain hose is obstructed, and water backs up into the analyzer, damage to the unit will occur resulting in costly repairs!

**2.** Route the hose along the leg of the equipment stand towards the floor, or as required for your installation configuration. Do not loop the drain hose or route it uphill. Cut off the excess hose. You may secure the hose with tie wraps (not supplied) or other suitable means if desired. Use caution so as not to crush the drain hose.

# INSTALLATION PROCEDURES

## SECTION 4

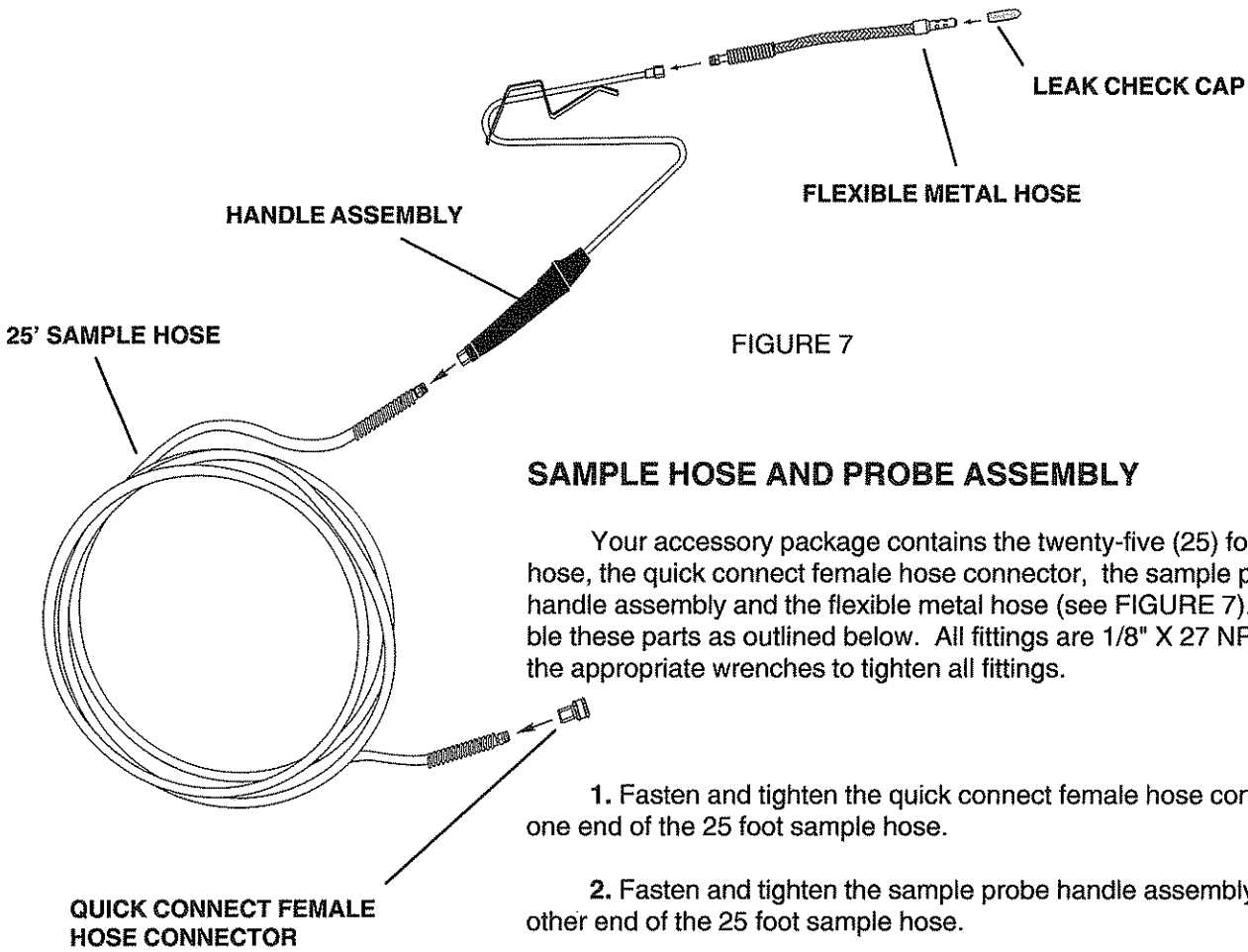



FIGURE 7

### SAMPLE HOSE AND PROBE ASSEMBLY

Your accessory package contains the twenty-five (25) foot sample hose, the quick connect female hose connector, the sample probe handle assembly and the flexible metal hose (see FIGURE 7). Assemble these parts as outlined below. All fittings are 1/8" X 27 NPT. Use the appropriate wrenches to tighten all fittings.

**1.** Fasten and tighten the quick connect female hose connector to one end of the 25 foot sample hose.

**2.** Fasten and tighten the sample probe handle assembly to the other end of the 25 foot sample hose.

**3.** Fasten and tighten the flexible metal hose to the end of the sample probe handle assembly.

**NOTE**

The flexible metal hose is used for the majority of automotive and light truck applications. It is inserted into the vehicle's tail pipe. An anti-dilution adapter is available for those applications where access is provided for exhaust gas sampling ahead of the catalytic converter. As an example, some mid 70's Chrysler Corporation vehicles provide a removable plug on the front (engine side) of the catalytic converter for this purpose. (See the **REPLACEMENT PARTS** section of this manual.)

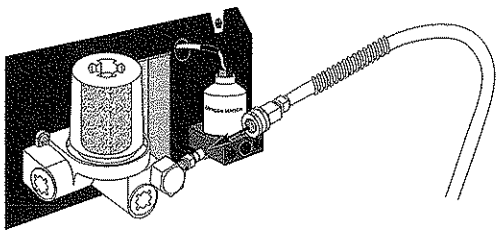


FIGURE 8:
**SAMPLE HOSE CONNECTION**

**4.** Connect the sample hose to the analyzer at the **EXHAUST GAS INput** connector on the rear of the analyzer (see figure 8).

**5.** Prior to using your analyzer for the first time, perform the **LEAK CHECK** test as outlined later in this manual to confirm the assembly integrity of the sample hose and probe.

# PACKING MATERIALS

## SECTION 5

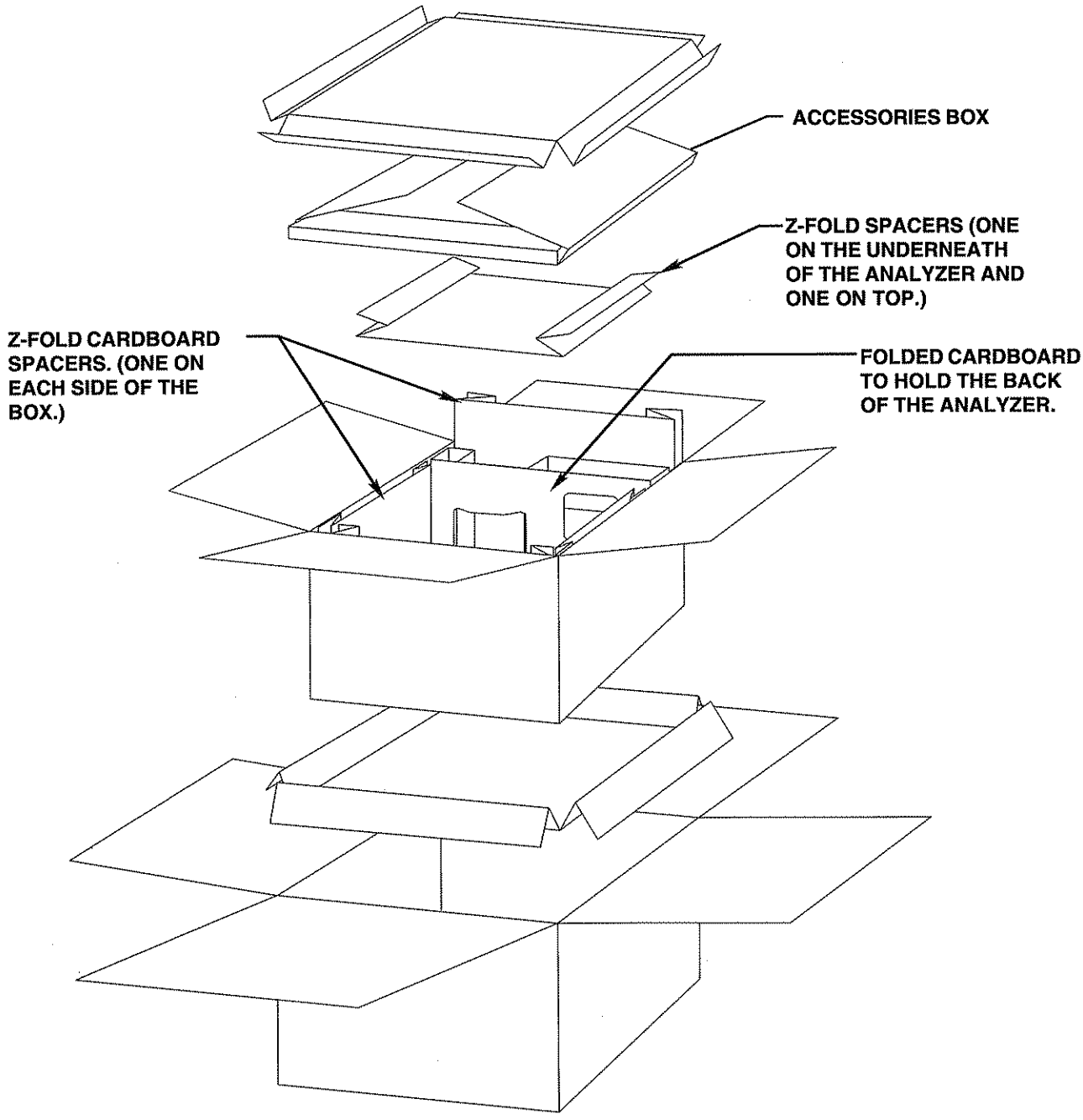


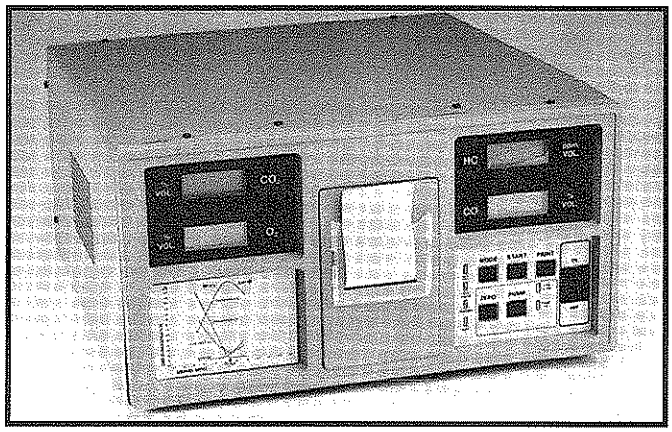

FIGURE 9:
**PACKAGING DIAGRAM**

### Do not discard any of the packaging from your analyzer!

You have purchased a precision and delicate instrument. In the event that it ever needs to be returned to the factory for service, package it carefully in the original shipping containers to ensure maximum protection. (See FIGURE 9 above.)

# DESCRIPTION

## SECTION 6



### (4) GAS EMISSIONS ANALYZER

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**This analyzer meets the BAR 90 specification for accuracy.**

The FOUR (4) GAS INFRARED EXHAUST ANALYZER is an easy to operate instrument that has been designed for fast and accurate testing of spark ignited, gasoline powered engines through the sampling of four (4) of the gasses present in the exhaust of the engine. The sampled gasses are: Carbon Monoxide (**CO**), Hydrocarbon (**HC**), Carbon Dioxide ($CO_2$), and Oxygen ($O_2$).

This instrument is ideally suited for checking combustion efficiency and emission levels on both catalytic converter equipped, and non-converter equipped vehicles. Your unit has been carefully assembled, tested, and factory calibrated with BAR 90 specified low concentration calibration gas. The unit is supplied with a twenty-five (25) foot sample hose and probe assembly, dust cover, and power cord for connection to an A.C. power source.

The built-in printer provides a hard copy of emission level test results, as well as help and error messages that guide the operator through the complete operation of the analyzer.

A dust cover is included to help keep your analyzer clean. Do not turn the analyzer **ON** with the dust cover in place! This will restrict ventilation. The unit will overheat, and damage may result.

### FOUR GAS ANALYZER FRONT PANEL CONTROLS, DISPLAYS, AND INDICATORS

(See FIGURE 10 on next page.)

**1. CO % VOL. Display -** LED (Light Emitting Diode) display indicates carbon monoxide content of exhaust gas from 00.00% - 10.00%.

**2. HC ppm Display -** LED (Light Emitting Diode) display indicates hydrocarbon content of exhaust gas from 0000 - 9999 parts per million.

**3. $CO_2$ % VOL. Display -** LED (Light Emitting Diode) display indicates carbon dioxide content of exhaust gas from 00.00% - 20.00%.

**4. $O_2$ % VOL. Display -** LED (Light Emitting Diode) display indicates oxygen content of exhaust gas from 00.00% - 25.00%.

**5. SELECT Switch -** When depressed, this switch toggles (cycles) the analyzer through its four (4) basic modes of operation. Detailed instruction on using each of these modes of operation will be covered in subsequent sections of this manual. These modes are indicated by the LED indicators described later in this section of the manual.

Upon completion of its initial self-checks and warm-up after the **POWER** switch is turned **ON**, the analyzer defaults to the **RUN** mode.

The four (4) basic modes of operation are as follows:

**A. RUN (Exhaust sampling) Mode -** This is the analyzer's exhaust sampling mode of operation. When all initial automatic power up checks have successfully executed, the analyzer will automatically switch to this mode. The analyzer is now ready for use. At this time the green **RUN** LED will be illuminated.

# DESCRIPTION

## SECTION 6

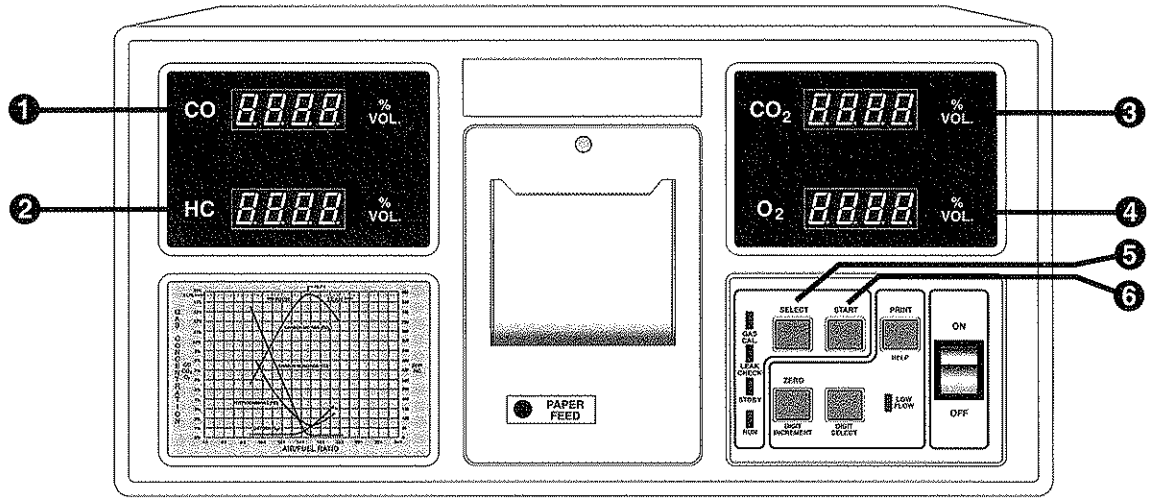



FIGURE 10:
**FRONT PANEL CONTROLS, DISPLAYS, AND INDICATORS**

**B. GAS CALibration Mode -** This mode of operation allows the user to perform a gas calibration of the analyzer using known concentrations of exhaust gasses. The yellow **GAS CAL.** LED will illuminate when this mode is selected, and will flash when the **START** switch is depressed.

**C. LEAK CHECK Mode -** This mode of operation allows the user to select an automated leak check of the exhaust gas sampling system. The yellow **LEAK CHECK** LED will illuminate when this mode is selected, and will flash when the **START** switch is depressed.

**D. STanDBY Mode -** This mode of operation turns off the displays as well as other non-essential circuits, thereby putting the analyzer into a power saving mode. This mode will also help extend the life of the analyzer. The yellow **STanDBY** LED will illuminate when this mode is selected, and will flash when the **START** switch is depressed.

**6. START Switch -** When depressed, this switch performs functions as indicated below based upon the **OPERATIONAL MODE** currently in effect as selected by the **SELECT** Switch.

**A. RUN Mode -** The **START** switch performs no function in the **RUN** (exhaust sampling) mode of operation.

**B. GAS CALibration Mode -** In the gas calibration mode of operation, the **START** switch initiates (begins) the automatic gas calibration sequence. During the calibration cycle, the **GAS CAL** LED will flash. A message will print out at the end of the gas calibration cycle indicating whether or not the analyzer has **COMPLETED** or **FAILED** the calibration.

**C. LEAK CHECK Mode -** In the leak check mode of operation, the **START** switch initiates the leak check function. During the leak check mode the **LEAK CHECK** LED will flash. Upon completion of this check the analyzer will automatically return to the **RUN** (exhaust sampling) mode of operation. A message will print out at the end of the leak check indicating whether or not the analyzer has **PASSED** or **FAILED** the leak check.

**D. STanDBY Mode -** In the standby mode of operation, the **START** switch initiates the standby function. During the standby mode the **STanDBY** LED will flash. To exit the standby mode press the **SELECT** switch. Upon exiting the **STanDBY** mode of operation, the analyzer will go through a zero cycle automatically.

# SECTION 6

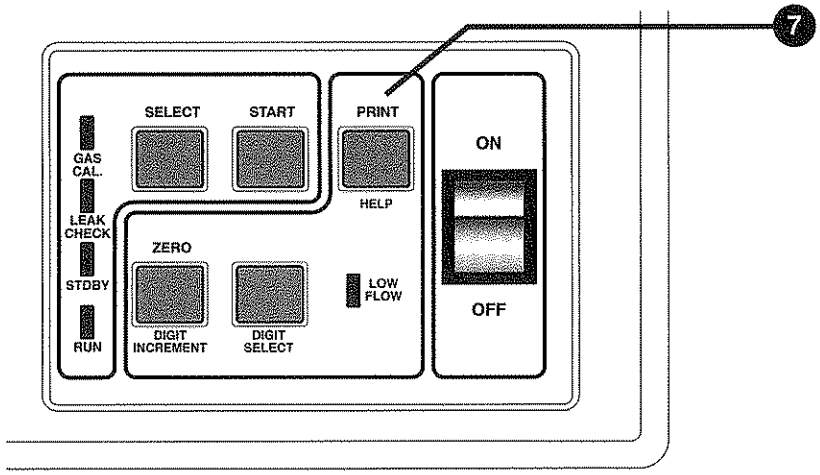



FIGURE 11:
**FRONT PANEL CONTROLS**

**7. PRINT Switch -** (see FIGURE 11) When depressed, this switch causes the analyzer's printer to print either sample exhaust readings, or basic help messages **prior to depressing the START switch**, as indicated below, depending upon the **OPERATIONAL MODE** currently in effect as selected by the **SELECT** switch.

**A. RUN Mode -** When the **PRINT** switch is depressed in the **RUN** (exhaust sampling) mode, it will direct the printer to print out the readings shown on the four (4) LED displays. A sample printout is shown below. The first five lines of the printout are provided for the technician or service writer's convenience.

```
FOUR GAS ANALYSIS
CUST:_____
DATE:_____
VEH:_____
VIN:_____
TECH:_____

CO2  =  11.80  %
CO   =   1.12  %
O2   =   2.35%
HC   =   0243  PPM
```

**B. GAS CALibration Mode -** When the **PRINT** switch is depressed in the gas calibration mode of operation, it will direct the printer to print the following help message:

```
GAS CALIBRATE MODE:

1.  USE DIGIT
INCREMENT AND SELECT
TO ENTER CAL GAS
VALUES

2.  OPEN CAL GAS VALVE

3.  PRESS START
```

**C. LEAK CHECK Mode -** When the **PRINT** switch is depressed in the leak check mode of operation, it will direct the printer to print the following help message:

```
LEAK CHECK MODE

1. PLACE LEAK CHECK
CAP OVER PROBE TIP

2. PRESS START
```

**D. STanDBY MODE -** When the **PRINT** switch is depressed in the standby mode of operation, it will direct the printer to print the following message:

# DESCRIPTION

## SECTION 6

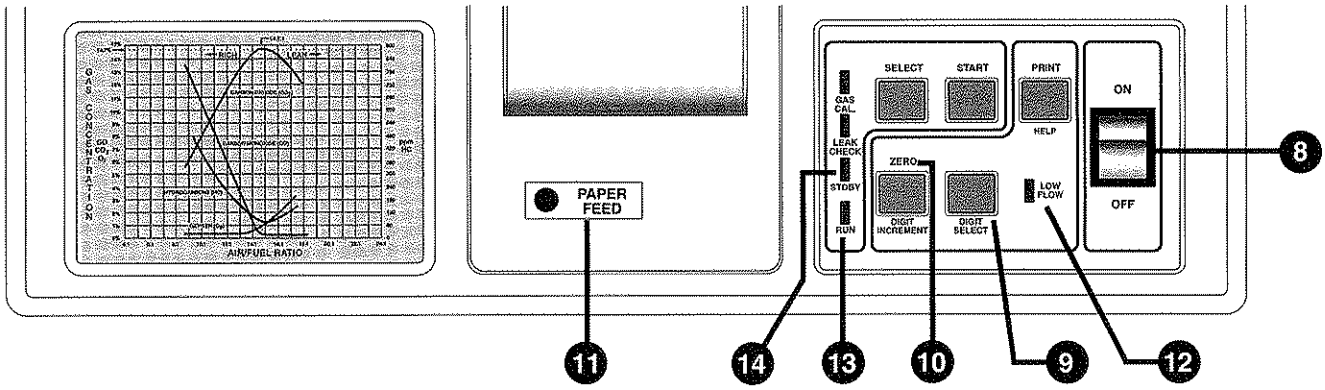



FIGURE 12:
**FRONT PANEL CONTROLS, DISPLAYS, AND INDICATORS**

STANDBY MODE

1. PRESS START TO ENTER STANDBY MODE

2. PRESS SELECT TO RETURN TO RUN MODE

**8. ON / OFF (Power) Switch -** (see FIGURE 12) Depress the bottom of this rocker switch to turn the analyzer **OFF**, or the top of the switch to turn it **ON**.

**9. DIGIT SELECT Switch -** This switch is functional in the **GAS CALibration** mode of operation only. When depressed, it will advance the display to the next selected digit for input of calibration gas values. This function is fully explained in the **CALIBRATION** section of this manual.

**10. ZERO Switch -** This switch is functional in the **RUN** and **GAS CALibration** modes of operation only as explained below.

**A. RUN Mode -** When the **ZERO** switch is depressed in the **RUN** (exhaust sampling) mode, it will directs the analyzer to draw in ambient (outside) air through the **ZERO AIR** input port on the rear of the analyzer. This purges the sampling system of any exhaust gas. The **CO**, **$CO_2$**, and **HC** LED displays are then zeroed, and **$O_2$** is set to the ambient level of approximately 21%. It is a good practice to re-zero the analyzer on a regular basis throughout the day while it is in use.

**B. GAS CALibration Mode -** When the **ZERO** switch is depressed in the gas calibration mode of operation, it will increment the displayed digit value during input of calibration gas values. This function is fully explained in the **CALIBRATION** section of this manual.

**11. PAPER FEED Switch -** When the paper feed switch is depressed, it directs the printer to advance (feed) printer paper one line at a time. If held down, it will feed paper continuously.

**12. LOW FLOW Indicator -** Red Light Emitting Diode (LED) illuminates whenever a low flow (restriction) is sensed in the analyzer's exhaust gas sampling system. This may be indicative of a clogged filter, a kinked hose, a restricted zero air input port, or a leak check cap which has not been removed from the sample probe.

**13. RUN Indicator -** Green Light Emitting Diode (LED) illuminates when the analyzer is in the run mode of operation.

**14. STanDBY Indicator -** Yellow Light Emitting Diode (LED) illuminates when the **STanDBY** function is selected, and flashes when the **STanDBY** function is entered (**START** switch is depressed). It also flashes when the **ZERO** function is selected.

# DESCRIPTION

## SECTION 6

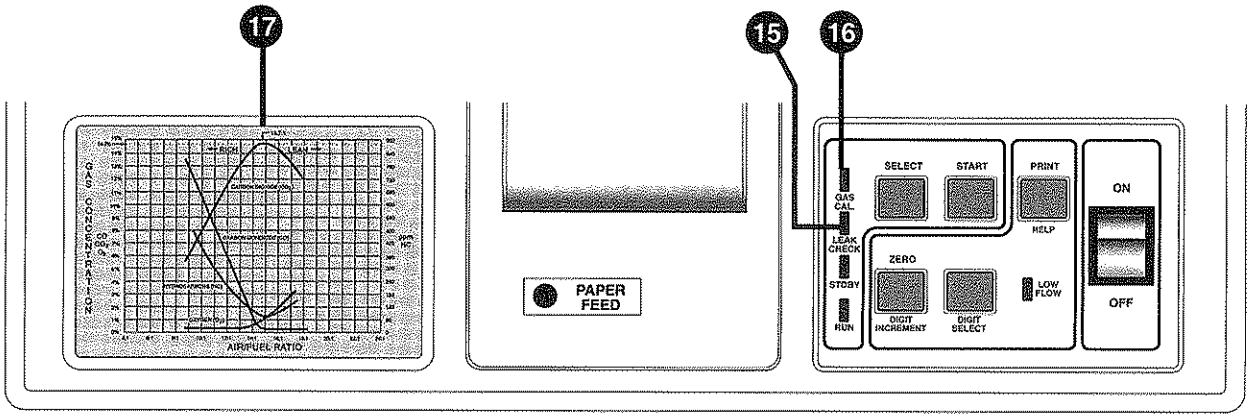



FIGURE 13:
**FRONT PANEL CONTROLS, DISPLAYS, AND INDICATORS**

**15. LEAK CHECK Indicator** - (see FIGURE 13) Yellow Light Emitting Diode (LED) illuminates when the **LEAK CHECK** function is selected, and flashes when the **LEAK CHECK** function is entered (**START** switch is depressed).

**16. GAS CAL. Indicator** - Yellow Light Emitting Diode (LED) illuminates when the **GAS CALibration** function is selected, and flashes when the **GAS CALibration** function is entered (**START** switch is depressed).

**17. STOICHIOMETRY GRAPH** - This decal graphically presents the relationship of the four (4) measured gasses; **CO, $CO_2$, HC,** and **$O_2$**.

## FOUR GAS ANALYZER REAR PANEL LAYOUT

(See FIGURE 14 on next page.)

**18. POWER CONNECTOR** - Connect the supplied A.C. power cable to this connector.

**19. VOLTAGE SELECTOR/FUSE COMPARTMENT** - This compartment contains two (2) user replaceable fuses, and the voltage selector module. **If fuse replacement becomes necessary, be sure to install only the size and type required by the setting of the voltage selector on the analyzer.** Voltage selection and fuse replacement are covered in the very beginning of this manual.

**20. COOLING FAN & FILTER ASSEMBLY** - The cooling fan maintains the interior temperature of the analyzer at a safe operating level. In order to maintain the efficiency of this fan and help extend the life of the analyzer, it is important to keep the fan filter clean. See the **MAINTENANCE** section of this manual for cleaning procedures.

**21. CALibration GAS Input Connection** - Connect the hose from the regulator assembly to this inlet fitting. Note that calibration gas input pressure must be maintained between 10 and 15 pounds per square inch (PSI). See the **CALIBRATION** section of this manual.

**22. ZERO AIR (Fresh air) Input Connection** - This connection supplies outside air to the analyzer

SECTION 6

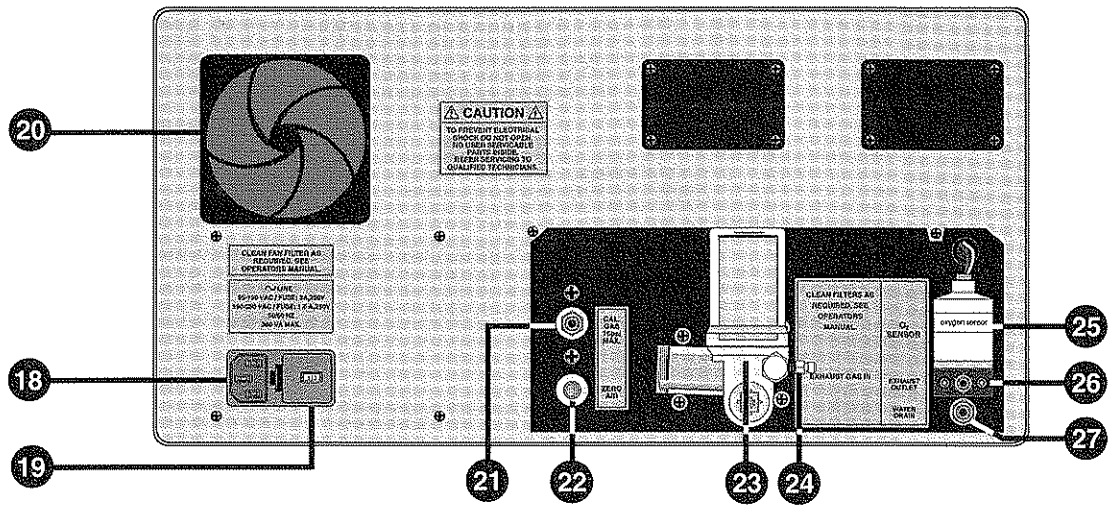



FIGURE 14:
**FOUR GAS ANALYZER REAR PANEL LAYOUT**

during the display zeroing function. If you suspect that the ambient air in which the analyzer is located is contaminated by exhaust gas from other vehicles, (as in a multi-bay garage for example) it may be advisable to attach a hose to this port and route it to the outside, so that the analyzer zeros in the cleanest available air. The zero air input port is threaded with 1/8" X 27 NPTF threads. The **REPLACEMENT PARTS** section of this manual contains a barbed fitting which will fit this port if desired. PVC tubing is also listed.

**23. TRI FILTER ASSEMBLY -** This filter assembly keeps contaminants out of the exhaust gas sample system. **It is important that this filter assembly be kept clean to maintain proper operation of the analyzer.** See the **MAINTENANCE** section of this manual for cleaning procedures.

**24. EXHAUST GAS SAMPLE HOSE CONNECTION -** This quick disconnect fitting provides the connection point for the supplied exhaust gas sample hose.

**25. OXYGEN ($O_2$) SENSOR -** This user replaceable oxygen sensor provides the analyzer with exhaust gas oxygen data. See the **MAINTENANCE** section of this manual for information on its life expectancy, and test and replacement procedures.

**26. EXHAUST OUTLET -** Sample exhaust gas from the vehicle under test is expelled from this port after having been analyzed. Like the zero air input port, the exhaust outlet is threaded with 1/8" X 27 NPTF threads. The **REPLACEMENT PARTS** section of this manual contains a barbed fitting which will fit this port if desired. PVC tubing is also listed.

**27. WATER DRAIN -** Water is a by-product of combustion, and is expelled from this outlet hose. To Avoid analyzer damage, make sure that the drain hose remains open and unobstructed!

# ERROR MESSAGES

## SECTION 7

Periodically during the operation of the analyzer various messages may be printed, indicating a problem or a condition which may need attention. Below is a listing of these messages, and a brief explanation of each.

**NOTE**

Some of the messages listed below may indicate a need for factory service. In order to obtain the fastest possible service, please have these messages in hand before contacting your technical support facility or factory service.

**1. GAS BENCH COMMUNICATION ERROR**

This message indicates that an internal electronic communication problem has occurred in the analyzer. Turn the analyzer off, wait a few seconds and turn the unit back on.

**2. GAS BENCH 15 MIN. WARMUP ERROR**

This message indicates that the analyzer's internal circuitry has failed to stabilize during the 15 minute warmup period. If the analyzer is stored in very cold conditions this message may be printed. Turn the analyzer off wait a few seconds and turn the unit back on.

**3. $O_2$ NOT CALIBRATED, CHECK ZERO INLET AND $O_2$ SENSOR**

This message indicates that a calibration error has occurred in the oxygen sensing system. Check the following:

**A.** If this message occurs at the end of the warmup cycle turn the analyzer off, wait a few seconds and turn the unit back on.

**B.** If this message occurs during gas calibration try performing the calibration again. Powering the analyzer off and then back on may also be necessary.

**C.** With the analyzer in the **RUN** mode, depress the **ZERO** button. Suction should be felt at the **ZERO AIR** inlet port on the rear of the analyzer. At the same time, air should be felt coming out of the **EXHAUST OUTLET** located at the end of the oxygen sensor mounting block.

**D.** Proceed to **OXYGEN SENSOR TEST AND REPLACEMENT PROCEDURES** as outlined in the **MAINTENANCE** section of this manual.

**4. CALIBRATION ERROR**
**CHECK GAS VALVE, GAS FITTINGS, GAS BOTTLE**

This message occurs during the automatic calibration cycle, and indicates that a calibration error has occurred during this cycle. The error can be pneumatic or electronic. Check the following:

**A.** All calibration gas tank, regulator, and hose fittings must be clean, tight, and properly connected.

**B.** The calibration gas tank's regulator must be set between 10 and 15 psi.

**C.** The calibration gas tank must have gas in it.

**D.** Perform the gas calibration again. Powering the analyzer off and then back on may also be necessary.

### 5. CAL GAS ERROR WITH ENTERED TAG VALUE

This message will always appear with message 5A, 5B, or 5C, or some combination of them. It is explained below in 5A, 5B, and 5C.

#### A. $CO_2$ OUT OF LIMITS

This message indicates that the value of carbon dioxide that was entered into the analyzer during the calibration gas value entry procedure was outside of the programmed limits of the analyzer. Double check the tank's value and your entry. Note that the lower limit calibration value of carbon dioxide is 5% and the upper limit is 15%.

#### B. CO OUT OF LIMITS

This message indicates that the value of carbon monoxide that was entered into the analyzer during the calibration gas value entry procedure was outside of the programmed limits of the analyzer. Double check the tank's value and your entry. Note that the lower limit calibration value of carbon monoxide is .9% and the upper limit is 8.5%.

#### C. HC OUT OF LIMITS

This message indicates that the value of propane that was entered into the analyzer during the calibration gas value entry procedure was outside of the programmed limits of the analyzer. Double check the tank's value and your entry. Note that the lower limit calibration value of propane is 286 ppm and the upper limit is 3148 ppm.

### 6. BENCH ZERO FAILED. CHECK FITTING AND ZERO GAS INLET

**A.** If this message printed during a zero cycle depress the **ZERO** switch.

**B.** If this message printed during gas calibration perform the gas calibration again.

**C.** With the analyzer in the **RUN** mode, depress the **ZERO** button. Suction should be felt at the **ZERO AIR** inlet port on the rear of the analyzer. At the same time, air should be felt coming out of the **EXHAUST OUTLET** located at the end of the oxygen sensor mounting block.

# HOOKUP, START AND WARM-UP

## SECTION 8

**CAUTION**

Before plugging your analyzer in for the first time, it is important to make sure that it is configured for the line voltage available in your location. **Incorrect line voltage selection can damage the unit!** See the beginning of this manual for complete instructions.

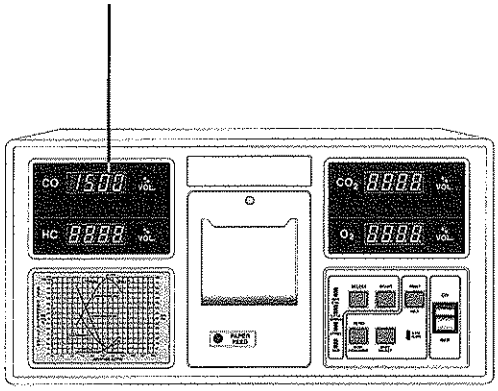
**1.** Make sure the power switch is in the OFF position.

**2.** Connect the analyzer to an appropriate A. C. power source.

**NOTE**

Under typical shop conditions, this analyzer has a warm up time of 3 to 10 minutes from a cold start-up. If the instrument is to be used regularly throughout the day, it is recommended that it be left on all day in the **STanDBY** mode when not in use.

FIGURE 15:
**Carbon monoxide (CO) display countdown during warmup.**



**2.** Depress the power switch to turn the unit **ON**. The following sequence of events will occur:

**A.** The printer will generate one line feed.

**B.** All display segments and LED annunciators will illuminate for a few seconds as a display check.

**C.** The carbon monoxide (CO) display will begin a countdown starting at 15 minutes, and 00 seconds. This indicates that the instrument is in its warmup cycle. Digits to the left of the decimal point represent minutes, and digits to the right of the decimal point represent seconds as shown (see FIGURE 15).

**D.** When the instrument's internal microprocessor has determined that all circuitry is sufficiently warm and stable, the analyzer will proceed to the automatic zeroing mode, as indicated by the **RUN** LED **ON**, and the **STanDBY** LED flashing. The pump will draw zero (outside) air into the exhaust gas sample system and, using this air as a "zero reference gas", will zero all the displays except oxygen ($O_2$), which will read approximately 21%.

**NOTE**

Ambient air (the air we breathe) contains approximately 21% oxygen.

**E.** Once this sequence is complete, the **STanDBY** LED will stop flashing, and the analyzer will be in the **RUN** mode of operation. The LED displays should indicate close to the following:

% CO = 0.00
% $CO_2$ = 0.00
PPM HC = 0
% $O_2$, approximately 21%

**NOTE**

It is normal for these readings to drift a minimal amount with time. This drift can be either positive (+) or negative (-) with respect to zero. While in the RUN mode the internal microprocessor will periodically initiate the zero cycle automatically. This feature will help to minimize the normal amount of drift. If it becomes excessive, press the zero switch to re-zero the analyzer.

# CAUTIONS ON ANALYZER USE

## SECTION 9

**1.** Diesel engines produce high levels of particulate matter. This analyzer should **not** be used for testing diesel engines since the excessive particulate emission levels will quickly and severely clog the entire exhaust gas sampling system resulting in costly repairs!

**2. NEVER INSERT THE EXHAUST SAMPLE PROBE INTO THE TAILPIPE OF A COLD ENGINE!** Cold engines produce excessive pollutants and water vapor which will quickly clog the tri filter assembly.

**3.** Any adjustments to the vehicle must be done in accordance with the vehicle manufacturer's instructions and within appropriate federal and state guidelines.

**4.** Due to the sensitivity and accuracy demanded from this unit, it is recommended that it be operated only from an equipment stand, or if a stand is not available, a sturdy, stable surface.

**5.** Do not use this analyzer in an unprotected (rain, snow, etc.) environment or in freezing conditions. Water vapor will freeze in the gas sampling system and restrict gas flow and/or damage the analyzer.

**6.** This analyzer is not approved for use on vehicles which are operated in confined or poorly ventilated areas (indoors).

# THE FOUR (4) SAMPLED GASSES

## SECTION 10

Listed below are the four (4) gasses that are sampled and displayed by the analyzer and a brief description of each.
(See FIGURE 16 on next page.)

### HYDROCARBON (HC)

All petroleum based products contain many hydrocarbon compounds. These compounds enter the atmosphere either through evaporation or exhaust. When HC is measured from the tailpipe, the measurement represents unburned fuel in parts per million of hydrocarbon (HC). Any condition which would cause the fuel not to burn completely such as a misfire due to either lean or rich mixture will contribute to a high HC reading. Insufficient spark or an incorrectly timed spark are common ignition problems that will cause high HC readings. Note that catalytic converters will reduce HC readings and mask problems.

### CARBON MONOXIDE (CO)

Carbon monoxide forms as a result of insufficient oxygen available during the combustion process (rich mixture). Unlike HC, CO only forms as the result of combustion. As an example, a lean misfire will produce excessive HC, but because there is no combustion, CO will not form. Conversely, a rich mixture will produce high HC and CO; high CO because of insufficient oxygen available to burn the fuel, and high HC because not all of the fuel was burned but rather was exhausted out of the tailpipe. High CO readings are typically the result of fuel system problems such as a dirty air filter, sticking choke, improper float setting, or a rich idle mixture setting. Specific to fuel injected engines, high readings may be caused by leaky injector(s), high fuel rail pressure, or a computerized engine control system malfunction. Note that as with HC, catalytic converters will reduce CO readings and mask problems.

### CARBON DIOXIDE ($CO_2$)

Carbon dioxide ($CO_2$) is an excellent indicator of combustion efficiency. Generally speaking, an engine is operating as efficiently as it can when carbon dioxide is at its peak value (%), regardless of whether or not the vehicle is equipped with a catalytic converter. This usually occurs in the range of 12% to 15%. Once any ignition malfunctions or other engine problems are solved, the $CO_2$ reading can assist in obtaining the proper carburetor mixture adjustment.

### OXYGEN ($O_2$)

The primary benefit of oxygen is that it indicates a lean condition. As the air/fuel ratio leans, the oxygen level will rise. If the mixture is leaned to the point of misfire, the $O_2$ level will rise quickly. Lean misfire is confirmed by observing HC and CO along with $O_2$. If CO is low, $O_2$ is high, and HC is high and unsteady, the engine is in a lean misfire condition.

# AIR/FUEL RATIO

## SECTION 11

At the center of all emission control techniques is the precise control of the air/fuel ratio. By closely controlling the air/fuel ratio, the engine will burn the mixture efficiently. The "ideal" or stoichiometric mixture is 14.7 pounds of air to 1 pound of fuel (commonly expressed 14.7 to 1). The stoichiometric point is shown on the graph (Figure 16) below.

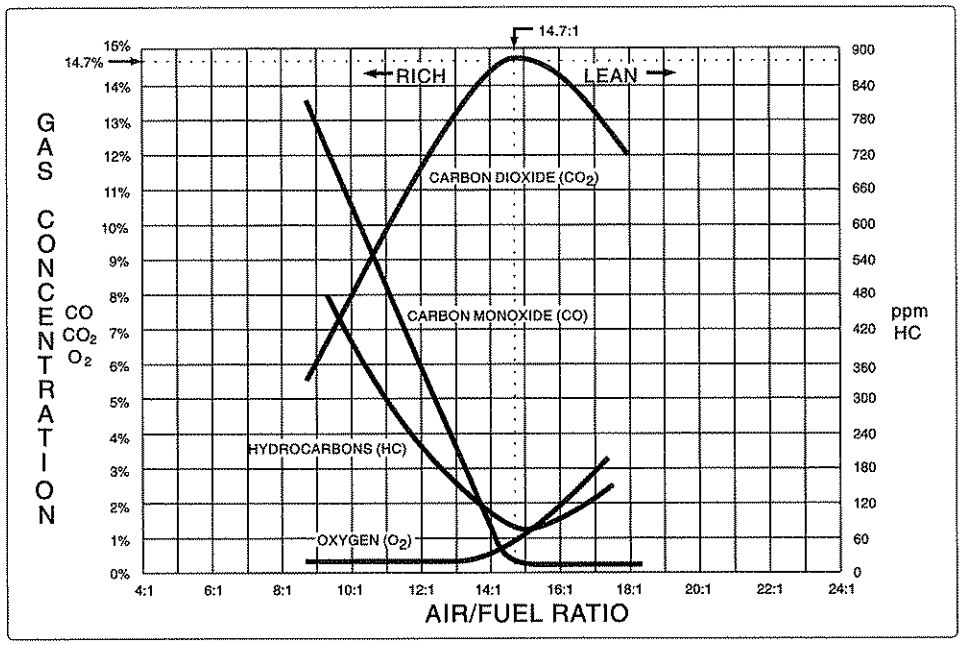



FIGURE 16:
**STOICHIOMETRY GRAPH**

# SAMPLING INSTRUCTIONS

## SECTION 12

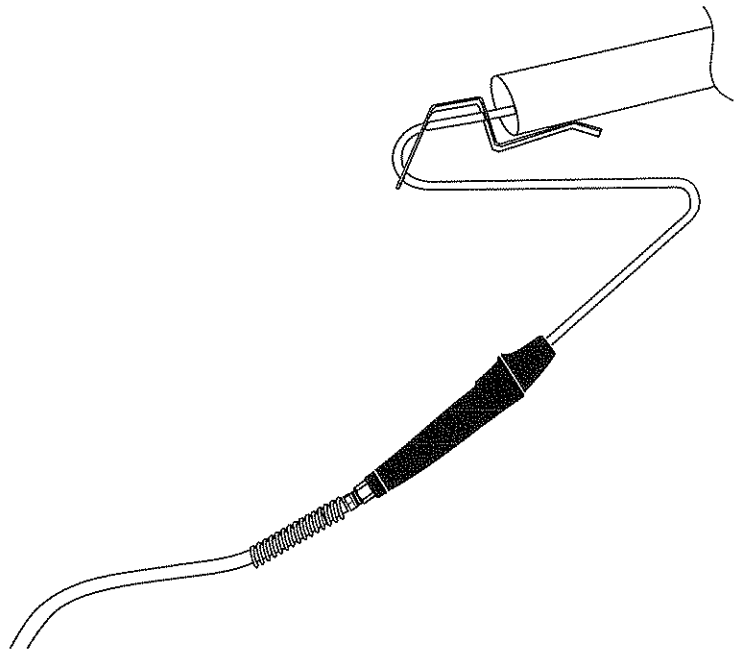


FIGURE 17:
**SAMPLE PROBE IN TAILPIPE**

### GENERAL EXHAUST GAS SAMPLING INSTRUCTIONS

**1.** Plug the analyzer into an appropriate A. C. power source and turn it **ON**. When all initial automatic power up checks have successfully executed, the analyzer will automatically switch to the **RUN** mode. The analyzer is now ready for use. At this time the green **RUN** LED should be illuminated.

**CAUTION**

**NEVER INSERT THE EXHAUST SAMPLE PROBE INTO THE TAILPIPE OF A COLD ENGINE!**

**2.** Fully warm the engine under test (upper radiator hose is hot) before inserting the sample probe into the tailpipe. Cold engines produce excessive pollutants and water vapor which can contaminate the analyzer quickly.

**3.** Unless specifically instructed otherwise by the vehicle service manual, disconnect the air injection system (air pump or pulseair). Leaving this system connected will alter the true exhaust readings.

**4.** Insert the sample probe into the tailpipe as shown in FIGURE 17. The clamp will hold the probe in place.

# SAMPLING INSTRUCTIONS

## SECTION 12

**5.** Allow the readings on the analyzer to stabilize and compare them to the manufacturer's specifications for the engine under test. If manufacturer's specifications are not available, see the **"TYPICAL EMISSION LIMIT GUIDELINES"** table below.

**6.** The print switch can be depressed at any time the analyzer is in the **RUN** mode to obtain a hard copy of the display readings.

**7.** If the **LOW FLOW** LED illuminates during testing, check the sample hose and probe assembly and the tri filter assembly for restrictions. See the **MAINTENANCE** section of this manual for further instructions.

**TYPICAL EMISSION LIMIT GUIDELINES**

Use these guidelines only if manufacturer's specifications are not available.

| YEAR | %CO | %CO2 | ppm HC | %O2 |
|---|---|---|---|---|
| 1968 - 1969 | Below 4% | Above 8% | Below 450 ppm | .1 - 4% |
| 1970 - 1974 | Below 3.5% | Above 8% | Below 450 ppm | .1 - 5% |
| 1975 - 1978 | Below 2% | Above 8% | Below 250 ppm | .1 - 5% |
| 1979 | Below 2% | Above 8% | Below 220 ppm | .1 - 5% |
| 1980 | Below 1.2% | Above 8% | Below 220 ppm | .1 - 5% |
| 1981 & Later (Idle) | Below 1.2% | Above 8% | Below 220 ppm | .1 - 5% |
| 1981 & Later (2500 RPM) | Below 1% | Above 8% | Below 200 ppm | .1 - 5% |

# CARBURETOR ADJUSTMENT

## SECTION 13

**NOTE**

All carburetor adjustments must follow manufacturer's instructions and specifications and also fall within any emission guidelines established by federal and/or state governments for the model year vehicle under test.

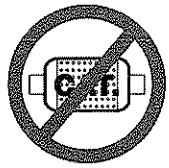
**NOTE**

When performing mixture adjustment on the fuel system (carburetor), turn the adjustment screws no more than 1/16th to 1/8th of a turn at a time, allowing the analyzer's displays to stabilize between adjustments.

## PRELIMINARY STEPS

**1.** Follow the appropriate vehicle service manual procedures for removing idle mixture screw limiter cap(s) or hardened plug(s) to gain access to the mixture adjustment screw(s).

**2.** In the case of a multibarrel carburetor (two mixture adjustment screws), lightly seat the screws and then back them out an equal number of turns. This balances the carburetor. A typical starting point is 1 -1/2 to 4 turns counterclockwise from a lightly seated position. Your vehicle service manual may recommend a specific starting point in which case that specification should be used.



**MIXTURE ADJUSTMENT (VEHICLES WITHOUT CATALYTIC CONVERTERS)**

**1.** Read and follow GENERAL TEST INSTRUCTIONS (ALL VEHICLES) through PRELIMINARY STEPS as listed above.

**2.** Set the curb idle speed as specified by the vehicle emission control label or vehicle service manual.

**3.** With the engine fully warmed and operating at curb idle, observe the readings on the analyzer. Pay particular attention to the HC and CO readings. If the mixture is rich, turn the mixture screw(s) clockwise to lean it. If the mixture is lean, turn the mixture screws counterclockwise to enrichen it. In the case of multibarrel carburetors, turn the mixture screws equally so that carburetor balance is maintained. Adjust the mixture so that HC is at a minimum level, and CO is low. This should simultaneously bring $O_2$ close to a minimum value, and $CO_2$ close to a maximum value. It may be necessary to readjust the curb idle speed during the mixture adjustment procedure. Check all idle adjustments when mixture adjustment is complete and reset as necessary.

**4.** When all adjustments are complete, be sure to reconnect the air injection system, and any other systems or devices disconnected for test purposes.


**MIXTURE ADJUSTMENT (VEHICLES WITH CATALYTIC CONVERTERS)**

**1.** Read and follow GENERAL TEST INSTRUCTIONS (ALL VEHICLES) through PRELIMINARY STEPS as listed above.

**2.** Set the curb idle speed as specified by the vehicle emission control label or vehicle service manual.

**3.** With the engine fully warmed and operating at curb idle, observe the readings on the analyzer. Because the catalytic converter reduces HC and CO, these two (2) gasses are not a true indicator of the engine's emission levels. Note that these gasses are reduced by the converter, not eliminated, and therefore the readings can be helpful. The carburetor can be more accurately adjusted by observing $O_2$ and CO. A lean mixture is evident by excessive $O_2$, and a rich mixture is evident by low to no $O_2$ and excessive CO. If the mixture is rich, turn the mixture screw(s) clockwise to lean it, if the mixture is lean, turn the mixture screws counterclockwise to enrichen it. In the case of multibarrel carburetors, turn the mixture screws equally so that carburetor balance is maintained. Lean the mixture while observing the $O_2$ display. When $O_2$ begins to rise sharply, the engine has reached the point of lean misfire. At this point, enrichen the mixture until $O_2$ drops back, and CO is at a low level. This should simultaneously bring $CO_2$ close to a maximum value and HC to a reasonably low level. It may be necessary to readjust the curb idle speed during the mixture adjustment procedure. Check all idle adjustments when mixture adjustment is complete and reset as necessary.

**4.** When all adjustments are complete be sure to reconnect the air injection system, and any other systems or devices disconnected for test purposes.

# MISCELLANEOUS TESTS

## SECTION 14

### CARBURETOR MIXTURE TEST (HIGH RPM)

With the vehicle in neutral or park, run the engine at 2000 to 2500 RPM and observe the $O_2$ reading. The readings for vehicles with catalytic converters and mechanical carburetors should range from 1.0% to 4.0% $O_2$. Readings of over 4.0% $O_2$ indicate an excessively lean mixture, while readings under 1.0% indicate an excessively rich mixture. Electronically controlled carburetors should show less than 1.0% $O_2$, and approximately 1.0% CO to maintain good drivability and low emission levels.

### AIR INJECTION SYSTEM TEST

The level of $O_2$ in the exhaust can be used to determine if the air pump is working on emission controlled vehicles. With the engine running and the air pump operating, observe the level of $O_2$ shown on the display. Disconnect the air pump or pinch off the outlet hose if possible. If the $O_2$ level drops by 2.0% to 5.0% from the previous reading, then the air pump is working correctly.

### CATALYTIC CONVERTER TEST

On a properly tuned vehicle with a catalytic converter, the $O_2$ will be approximately equal to the CO. If the $O_2$ level exceeds the CO level, and the CO reading is above .5% then the catalytic converter is malfunctioning.

### ACCELERATOR PUMP TEST

Adjust the engine speed to approximately 1000 RPM and allow the readings on the analyzer to stabilize. Snap accelerate the engine while observing the HC and CO displays. These readings should rise sharply and then return quickly to their original levels. If no significant increase is observed in these readings and/or the vehicle stumbles badly during heavy acceleration, it indicates that the accelerator pump is not operating correctly and the carburetor should be serviced accordingly.

### MANIFOLD LEAK TEST

The analyzer can be used to detect air leaks into the intake manifold when a vacuum gauge indicates abnormally low engine vacuum or when a lean misfire in one or two cylinders is suspected. With the engine operating at curb idle, squirt a small amount of solvent (carburetor cleaner) along the gasket and bolts of the intake manifold and at the base of the carburetor. Apply the solvent to limited areas at a time allowing time for the analyzer to react. When HC and CO rise sharply, the location of the leak has been determined.

### PCV VALVE TEST

Remove the PCV valve from the engine, but do not remove the hose leading to the intake manifold or base of the carburetor. Run the engine at idle while observing the CO and $O_2$ readings. If there is no change in the CO or $O_2$ readings, the PCV system is malfunctioning. An increase of 1.0% or more $O_2$, or a decrease of 1.0% or more CO, indicates too much crankcase dilution by either excessive blow-by gasses or a contamination of the oil by fuel.

# TEST RESULTS

## SECTION 15

## INTERPRETATION OF THE READINGS

**ENGINE CURB IDLE RPM RESULTS**

**Excessive CO readings can be caused by:**

1. Over advanced initial ignition timing.
2. Idle mixture adjustment too rich.
3. Restricted PCV system.
4. Curb idle RPM too low.
5. Restricted air filter.
6. Leaking carburetor accelerator pump or power circuits.
7. Air pump inoperative.
8. Sticking choke.
9. Malfunctioning emission control systems.
10. Engine not at normal operating temperature (too cold).
11. Restricted vapor canister filter.

**Excessive HC readings can be caused by:**

1. Over advanced initial ignition timing.
2. Excessive oil consumption.
3. Low cylinder compression.
4. Leaking gaskets (intake manifold, carburetor area).
5. Defective valves, guides, or lifters.
6. Defective rings, pistons, or cylinders.
7. Idle mixture adjustment too lean (lean misfire).
8. Idle mixture adjustment too rich (incomplete combustion).
9. Malfunctioning emission control systems.
10. Engine not at normal operating temperature (too cold).
11. Vacuum leak.
12. Unbalanced carburetor (mixture adjustment, multiple barrel only).

**Excessive HC and CO readings can be caused by:**

1. Idle mixture adjustment too rich (incomplete combustion).
2. Malfunctioning carburetor.
3. Engine not at normal operating temperature (too cold).

# TEST RESULTS

## SECTION 15

### INTERPRETATION OF THE READINGS

4. Excessive fuel pump pressure.
5. Vacuum leak.
6. Improper valve adjustment.

**Excessive $O_2$ with low CO readings can be caused by:**

1. Air pump left connected during testing.
2. Idle mixture adjustment too lean.
3. Vacuum leak.
4. Curb idle speed improperly set.
5. Metering rods improperly positioned.
6. Internal air or vacuum leak in the carburetor.
7. Restricted idle system.
8. Restricted main metering system.
9. Exhaust system leak(s).

**Excessive CO with low $O_2$ readings can be caused by:**

1. Idle mixture adjustment too rich.
2. Restricted air filter.
3. Sticking choke.
4. Restricted air bleeds.
5. Restricted PCV system.
6. Curb idle speed improperly set.
7. Vapor canister malfunctioning.

**Below normal $CO_2$ readings can be caused by:**

1. Incorrect idle mixture adjustment.
2. Restricted air filter.
3. Sticking choke.
4. Exhaust system leak(s).

**High $O_2$ low CO, HC, $CO_2$ .**

1. Diluted gas sample - Perform LEAK CHECK TEST. (See SECTION 16)

# LEAK CHECK

## SECTION 16

When the analyzer is **ON**, the Leak Check mode of operation will automatically check its pneumatic system for leaks. The automated leak check should be performed under the following conditions:

**A.** Immediately following reassembly of any portion of the sample exhaust filtering system.

**B.** Immediately following reassembly of any portion of the analyzer's pneumatic system.

**C.** Any time during exhaust testing that the carbon monoxide, carbon dioxide, and hydrocarbon readings are suspiciously low, and the oxygen reading is suspiciously high. This is an indication that outside air is entering the exhaust gas sample and diluting it. Check the vehicle's exhaust system for leaks. Once you have ascertained the integrity of the vehicle's exhaust system, proceed with the system leak check on the analyzer. Suspicious readings may also be caused by clogged filters.

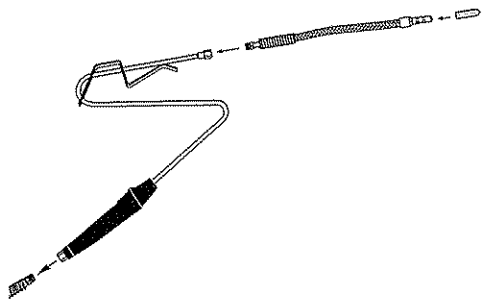


FIGURE 18:
**LEAK CHECK CAP INSTALLATION**

**NOTE**

The automated portion of the leak check cycle will take approximately 25 seconds.

**1.** Remove the exhaust sample probe from the vehicle's tailpipe (if inserted).

**2. SELECT** the Leak Check mode of operation, but **DO NOT press the START button!**

**3.** Using a clean dry rag, wipe the tip of the sample probe until it is clean. This will assure a tight seal between the leak check cap and the probe tip. Do not use a rag which is damp with any petroleum based solvents, as this may cause a hydrocarbon hangup problem in the analyzer.

**4.** Install the leak check cap on the end of the sample probe, making sure that it seals. See FIGURE 18.

**5.** Press the **START** button on the analyzer. The leak check LED flashes indicating the test is progress.

# LEAK CHECK

## SECTION 16

**6.** If the leak check passes, the analyzer will automatically return to the **RUN** mode and the following message will print:

```
LEAK TEST COMPLETED

SYSTEM PASSED

PLEASE REMOVE CAP
FROM PROBE TIP
```

As indicated, remove the leak check cap from the probe tip. The analyzer is now ready to resume vehicle testing.

**7.** If the leak check fails, the analyzer will automatically return to the **RUN** mode and the following message will print:

```
LEAK TEST FAILED

PLEASE REMOVE CAP
FROM PROBE TIP

CHECK: FITTINGS
HOSE
PROBE
FILTER ASSEMBLY
PROBE CAP

SEE INSTRUCTION
MANUAL
```

**8.** Leak check failure indicates a vacuum leak somewhere in the pneumatic system of the analyzer.

**A.** If the failure occurred immediately following tri filter maintenance, double check the reassembly of this filter for errors or leaks.

**B.** If the failure has occurred spontaneously, it will be necessary to systematically check the external pneumatic system. The following suggestions may help to uncover the source of the problem.

**1.** Remove the sample hose from the tri filter assembly at the quick disconnect fitting. Place your finger over the exposed opening of the fitting on the tri filter. While holding your finger in place over the opening, run the automated leak check procedure again (Steps 2 and 5 above). If the leak check passes, the problem is with the leak check cap or the sample hose and probe assembly. If the leak check still fails, then the problem is in the tri filter assembly, or inside the analyzer. Disassemble and check the integrity of all tri filter assembly components. Ensure that

all "O" rings, filter screens, and the filter element are in place and not damaged.

**2.** Check to see that the leak check cap is in good condition and that it is completely sealed on the probe tip.

**3.** Examine the sample probe and hose assembly. Make certain that threaded connections are tight and that there are no cracks or splits in, or other deterioration of, the hose.

**4.** If after all external checks are complete and the analyzer still fails the leak check test, make the following simple check: Remove the sample hose from the tri filter assembly at the quick disconnect fitting. Place your finger over the exposed opening of the fitting on the tri filter. While holding your finger in place over the opening, run the automated leak check procedure one last time (Steps 2 and 5 above). If little or no vacuum is felt, and/or the leak check still fails, it is very likely that the pump has failed, or there is an internal pneumatic system failure. Contact your technical support facility or factory service for assistance.

# HYDROCARBON HANGUP

## SECTION 17

Hydrocarbon hangup occurs as a result of fuel residues remaining in the pneumatic system of the analyzer. It is indicated by an **HC reading of 20 ppm or higher**, immediately following the analyzer's auto zero cycle. An explanation follows.

During the auto zero cycle, the analyzer draws fresh air through its **internal** pneumatic system from the **ZERO AIR** input port on the rear of the analyzer. The tri filter assembly, and the exhaust gas sample hose and probe assembly, are not included as part of this pneumatic circuit. This ensures that the analyzer sensing system is zeroed to uncontaminated ambient air. When the analyzer exits the auto zero cycle and enters the **RUN** mode, it automatically switches its pneumatic input from the **ZERO AIR** port to the **EXHAUST GAS IN**put port. If fuel residues have collected in the tri filter assembly or sample hose, the analyzer will display them on the **H**ydro**C**arbon display. The following procedure will determine the source of the hydrocarbon residue, and suggest solutions to the problem.

### HYDROCARBON HANGUP TEST

**1.** Connect the exhaust gas sample hose to the analyzer, and turn the analyzer **ON** if not already done.

**2.** When the analyzer is in the **RUN** mode allow the unit to run for five minutes to purge the sample hose and system.

**3.** With the exhaust gas sample hose drawing in fresh air depress the **ZERO** switch.

**4.** When the automatic zero cycle ends and the analyzer returns to the **RUN** mode, wait a few seconds and observe the **HC** display.

**5.** If the **HC** display climbs to a reading of **20 ppm** or greater, a hydrocarbon hangup problem exists. Follow steps 6 through 8 to help isolate the cause of the problem.

**6.** While the analyzer is in the **RUN** mode, and with the exhaust gas sample hose drawing in fresh air, remove the hose from the tri filter assembly on the rear of the analyzer.

**7.** Observe the **H**ydro**C**arbon display. If the value on the display decreases to near zero, then the sample hose contains excessive amounts of fuel residue. If there is very little change on the **HC** display, then the fuel residue problem is centered in the tri filter assembly. If the value on the display is cut approximately in half, then a fuel residue problem exists in both areas.

**8.** Service the sample hose and/or tri filter assemblies as outlined in the **MAINTENANCE** section 20 of this manual.

# CALIBRATION

## SECTION 18

Your analyzer shipped from the factory completely calibrated with low range BAR 90 approved gas. **To maintain BAR 90 accuracy, the analyzer should be recalibrated on location with this same specification of gas.** If, however, this gas is not available, BAR 84 approved calibration gas is the recommended substitute. The analyzer is capable of accepting individual gas concentrations within the ranges outlined below.

**C**arbon m**O**noxide .9% - 8.5%
**C**arbon di**O**xide **2** 5% - 15%
Propane ($C_3H_8$) 286 ppm - 3148 ppm

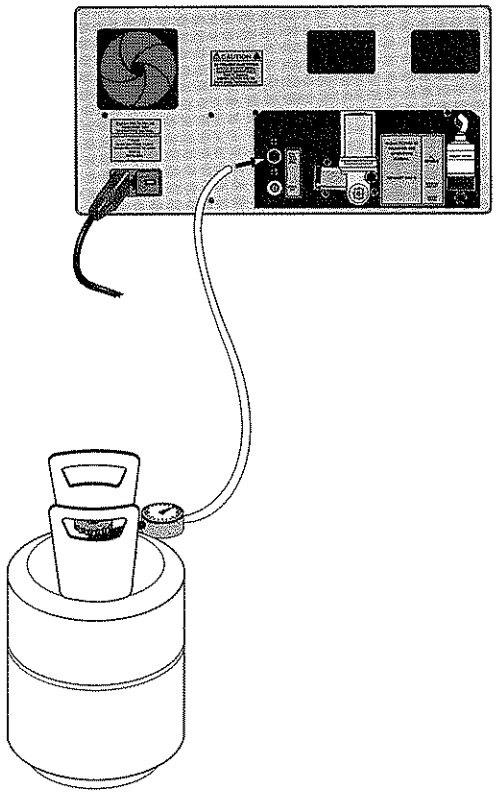


FIGURE 19:
**CALIBRATION GAS TANK HOOK-UP DIAGRAM**

**NOTE**

The calibration gas necessary to calibrate your instrument is available through your dealer or representative. This gas is supplied in a typical propane style container, but is non-refillable. Actual calibration gas flow is maintained for approximately 90 seconds during the analyzer's automated calibration process. This will result in approximately 100 calibration cycles per tank of gas with the regulator properly set at a pressure of 10 - 15 psi. **Note that this regulator setting range is essential to obtain an accurate calibration!**

**1.** Turn the analyzer **ON** and allow it to warm up, uninterrupted, for at least thirty (30) minutes. Allow it to proceed on its own to the **RUN** mode.

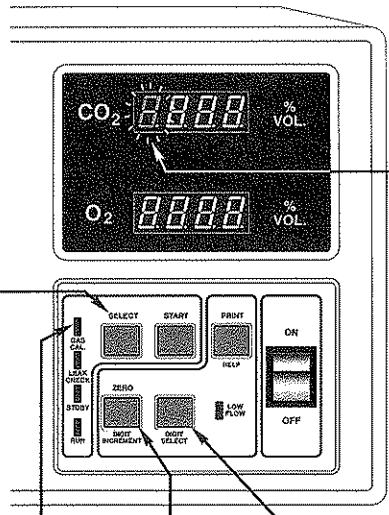
**2.** While the analyzer is warming up, connect the regulator assembly, hose, and calibration gas tank together as shown in FIGURE 19, if not already done. Connect the hose from the tank's regulator to the **CALibration GAS** barbed inlet fitting on the rear of the analyzer. After all plumbing connections are complete, confirm that your tank of calibration gas has gas in it by turning on the tank's valve, and then setting the regulated pressure between the recommended 10 - 15 psi limits. Once this value is set, turn the calibration tank's valve **OFF**. If you cannot reach at least a 10 psi reading on the regulator's gauge, your tank is, for all practical purposes, empty. **Do not proceed any further into the calibration procedure until a replacement tank of calibration gas is obtained!**

**3.** Have the gas concentration values (values of **CO**, **$CO_2$** , and **PROPANE** listed on the tank) from your tank of calibration gas on hand if this is the first calibration performed on the analyzer since its purchase, or the first calibration with these gas concentration values. These values will be entered into the analyzer as explained below.

**4.** Depress the **SELECT** switch until the **GAS CALIBRATION MODE** is active. The yellow **GAS CAL LED** will be illuminated, and the far left digit of the **$CO_2$ LED display** will flash (00.00). Note that if the displayed values on the analyzer match those listed on the tank of calibration gas, proceed directly to step 16 of this procedure.

# CALIBRATION

## SECTION 18




**Depress the SELECT switch until the gas calibration mode is active. The far left digit of the $CO_2$ LED display will FLASH.**

**Depress the SELECT switch anytime to exit the calibration procedure prior to depressing the START switch.**

**Yellow GAS CAL LED will illuminate when calibration mode is selected.**

**DIGIT INCREMENT switch changes the numeric value from 0 to 9.**

**DIGIT SELECT switch advances the displayed digit (tens, units, tenths etc).**

FIGURE 20:
**CALIBRATION PROCEDURE DIAGRAM**

## CALIBRATION PROCEDURE

**NOTE**

Should it become necessary to exit the calibration procedure you may do so by depressing the **SELECT** switch any time **prior** to depressing the **START** switch. (See FIGURE 20 .)

**5.** Depress the **DIGIT INCREMENT** switch until the flashing digit indicates the same value as the first (tens) digit of the **carbon dioxide** value on the calibration gas tank. Note that for carbon dioxide gas values of less than 10.00%, the first digit on the analyzer should be "**0**".

**6.** Depress the **DIGIT SELECT** switch. The second digit of the **$CO_2$ LED display** will flash (**0**0.00).

**7.** Depress the **DIGIT INCREMENT** switch until the flashing digit indicates the same value as the second (units) digit of the **carbon dioxide** value on the calibration gas tank.

**8.** Depress the **DIGIT SELECT** switch. The third digit of the **$CO_2$ LED display** will flash (00.**0**0).

**9.** Depress the **DIGIT INCREMENT** switch until the flashing digit indicates the same value as the third (tenths) digit of the **carbon dioxide** value on the calibration gas tank.

**10.** Depress the **DIGIT SELECT** switch. The fourth digit of the **$CO_2$ LED display** will flash (00.0**0**).

**11.** Depress the **DIGIT INCREMENT** switch until the flashing digit indicates the same value as the fourth (hundredths) digit of the **carbon dioxide** value on the calibration gas tank.

**12.** Depress the **DIGIT SELECT** switch. The first digit of the **CO LED display** will flash (**0**0.00).

**13.** Depress the **DIGIT INCREMENT** switch until the flashing digit indicates the same value as the first (tens) digit of the **carbon monoxide (CO)** value on the calibration gas tank.

**14.** Continue the gas value entry procedure as instructed above until all three (3) gas input values on the analyzer, **H**ydro**C**arbon, **C**arbon m**O**noxide, and **C**arbon Di**O**xide **2**, match the values on the tank of calibration gas.

**NOTE**

As there is no oxygen in any tank of approved calibration gas, the $O_2$ value shown on the display will always be zero during the calibration process. This value is not adjustable. The analyzer will calibrate itself based upon the amount of oxygen in ambient air, and based on that, should display a value of approximately 21% at the end of the calibration cycle.

**15.** Once the last gas value has been entered, which is the fourth digit (0000) on the **HC** display, double check the entries for accuracy and make any necessary corrections. To correct the entry of any given digit, depress the **DIGIT SELECT** switch until the incorrect digit is flashing, and then press the **DIGIT INCREMENT** switch until the value is correct.

**16.** Turn on the gas container valve. Check that the gauge on the regulator shows a gas pressure of 10 - 15 psi. Readjust if necessary.

**17.** Depress the **START** switch (see FIGURE 20 ). The analyzer will store the gas values for the next time the unit is calibrated, perform gas and zero calibrations and return to the normal operating mode. During the automatic calibration cycle, the **GAS CAL** LED will flash. **The automatic calibration cycle will take approximately 75 seconds.** Turn off the valve on the gas container's regulator when instructed to do so by the analyzer printer's message. You may leave the calibration gas tank and hose connected to the analyzer if you desire. Calibration gas input to the analyzer is controlled by a solenoid activated valve inside the analyzer.

**NOTE**

Keep in mind that once all gas values have been entered, **and the automatic calibration procedure has successfully executed**, the gas values that you have entered will remain in the analyzer's memory, even when the unit is turned OFF or unplugged. Therefore it is not necessary to reenter gas values prior to subsequent calibrations unless you purchase calibration gas whose gas concentrations (gas values) are different from the previously used tank of gas.

# CALIBRATION ERROR MESSAGES

## SECTION 19

## CALIBRATION RELATED ERROR MESSAGES

**1. $O_2$ NOT CALIBRATED, CHECK ZERO INLET AND $O_2$ SENSOR**

This message indicates that a calibration error has occurred in the oxygen sensing system. Check the following:

**A.** If this message occurs at the end of the warmup cycle turn the analyzer off, wait a few seconds and turn the unit back on.

**B.** If this message occurs during gas calibration try performing the calibration again. Powering the analyzer off and then back on may also be necessary.

**C.** With the analyzer in the **RUN** mode, depress the **ZERO** button. Vacuum should be felt at the **ZERO AIR** inlet port on the rear of the analyzer. At the same time, air should be felt coming out of the **EXHAUST OUTLET** located at the end of the oxygen sensor mounting block.

**D.** Proceed to **OXYGEN SENSOR TEST AND REPLACEMENT PROCEDURES** as outlined in the **MAINTENANCE** section of this manual.

**2. CALIBRATION ERROR**
**CHECK GAS VALVE, GAS FITTINGS, GAS BOTTLE**

This message occurs during the automatic calibration cycle, and indicates that a calibration error has occurred during this cycle. The error can be pneumatic or electronic. Check the following:

**A.** All calibration gas tank, regulator, and hose fittings must be clean, tight, and properly connected.

**B.** The calibration gas tank's regulator must be set between 10 and 15 psi.

**C.** The calibration gas tank must have gas in it.

**D.** Perform the gas calibration again. Powering the analyzer off and then back on may also be necessary.

**3. CAL GAS ERROR WITH ENTERED TAG VALUE**

This message will always appear with message 3A, 3B, or 3C, or some combination of them. It is explained below in 3A, 3B, and 3C.

**A. $CO_2$ OUT OF LIMITS**

This message indicates that the value of carbon dioxide that was

entered into the analyzer during the calibration gas value entry procedure was outside of the programmed limits of the analyzer. Double check the tank's value and your entry. Note that the lower limit calibration value of carbon dioxide is 5% and the upper limit is 15%.

**B. CO OUT OF LIMITS**

This message indicates that the value of carbon monoxide that was entered into the analyzer during the calibration gas value entry procedure was outside of the programmed limits of the analyzer. Double check the tank's value and your entry. Note that the lower limit calibration value of carbon monoxide is .9% and the upper limit is 8.5%.

**C. HC OUT OF LIMITS**

This message indicates that the value of propane that was entered into the analyzer during the calibration gas value entry procedure was outside of the programmed limits of the analyzer. Double check the tank's value and your entry. Note that the lower limit calibration value of propane is 286 ppm and the upper limit is 3148 ppm.

**4. BENCH ZERO FAILED. CHECK FITTING AND ZERO GAS INLET**

**A.** If this message printed during a zero cycle depress the **ZERO** switch.

**B.** If this message printed during gas calibration perform the gas calibration again.

**C.** With the analyzer in the **RUN** mode, depress the **ZERO** button. Vacuum should be felt at the **ZERO AIR** inlet port on the rear of the analyzer. At the same time, air should be felt coming out of the **EXHAUST OUTLET** located at the end of the oxygen sensor mounting block.

# SECTION 20

NOTE

The analyzer should be turned **OFF** and unplugged during any maintenance procedures.

NOTE

It is advisable to perform the automated **LEAK CHECK** after any disassembly and reassembly has occurred in the exhaust gas sampling/ pneumatic system.

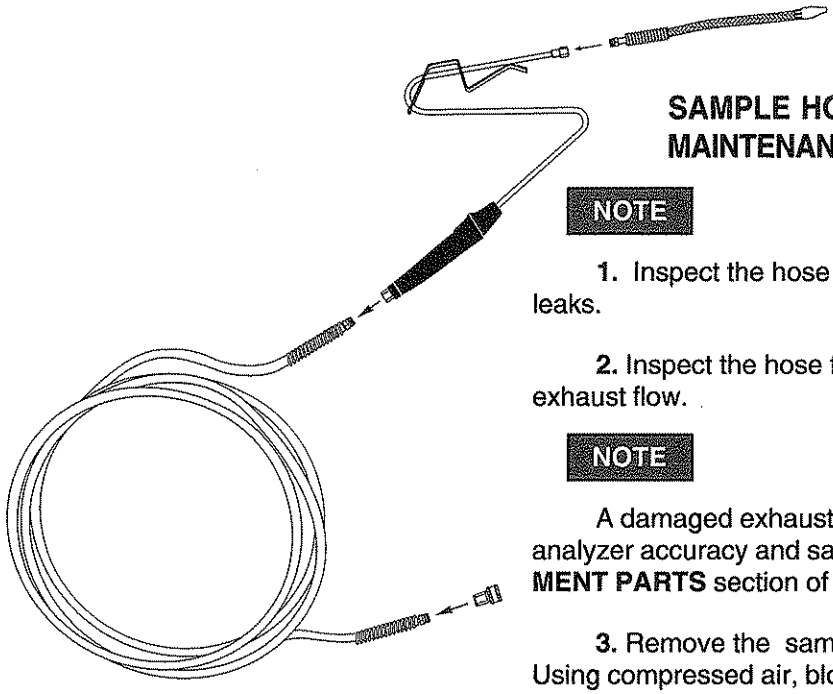


FIGURE 21:
**SAMPLE HOSE AND PROBE ASSEMBLY - MAINTENANCE**

## SAMPLE HOSE AND PROBE ASSEMBLY - MAINTENANCE

NOTE

**1.** Inspect the hose for cuts or abrasions which may cause air leaks.

**2.** Inspect the hose for kinking or crushed sections that may restrict exhaust flow.

NOTE

A damaged exhaust gas sample hose must be replaced to maintain analyzer accuracy and sampling system integrity. See the **REPLACEMENT PARTS** section of this manual.

**3.** Remove the sample hose from the tri filter assembly fitting. Using compressed air, blow through the hose from the quick disconnect end to dislodge any dirt or carbon which may have accumulated inside of the hose. Do not use compressed air on the analyzer or filtering system as internal damage may occur.

**4.** Check the holes at the end of the sample probe to make sure they are free from dirt and carbon.

**5.** If you have determined that the sample hose and probe assembly are responsible for a hydrocarbon hangup problem as described previously in this manual, it may be necessary to clean the assembly as follows:

**A.** Remove the sample hose and probe assembly from the analyzer, and the female quick connect fitting from the end of the sample hose. Remove the sample probe from the hose.

**B.** Prepare a moderately strong solution of soapy water in a container large enough to completely submerge the loosely coiled hose. **Do not use petroleum based solvents for cleaning purposes, as this will worsen the problem!** Completely submerge the hose in the

soap solution making sure that the cleaning solution flows into the entire hose. Allow it to soak for several hours, or overnight. Rinse the hose thoroughly with clean water, and then completely dry the inside of the hose with clean dry compressed air.

**C.** When you are certain that the inside of the sample hose is dry, reinstall the sample probe and the female quick connect fitting on the hose. Reinstall the sample probe and hose assembly on the analyzer.

**D.** Repeat the Hydrocarbon Hangup test to see if the problem has been solved. If it has not, it may be necessary to replace the sample hose, and/or filtering system parts as required to restore proper operation. Contact your technical support facility or factory service for further assistance.

## TRI FILTER ASSEMBLY - MAINTENANCE

**CAUTION**

Do not use petroleum distillate solvents to clean any part of the tri filter assembly. Some solvents of this type may react adversely with the poly-sulfone assembly, and cause either physical damage, or create a hydrocarbon (**HC**) hang up problem. Hydrocarbon hang up is evident when the **HC** display on the analyzer drifts excessively off of "0" (approximately 20 ppm) when drawing in fresh air, **after** it has exited an automatic zero cycle. It is caused by solvent and/or its residues remaining in the exhaust gas sample system.

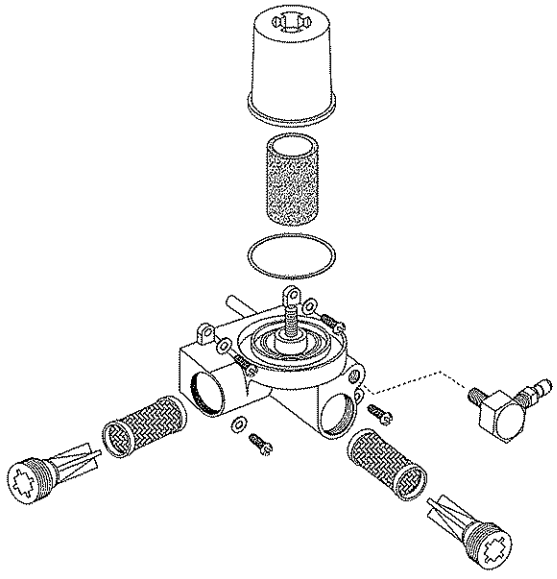


FIGURE 22:
**TRI FILTER ASSEMBLY DIAGRAM**

**NOTE**

All three (3) sections of the tri filter assembly are easily disassembled and reassembled with a 3/8" square drive extension. When reassembling the filter parts, do not overtighten the filter bowl or screen filter retainers. Damage to the filter assembly or related parts is not covered by the warranty.

Inspect the tri filter assembly daily for contamination, and maintain it as indicated below. (See FIGURE 22)

**1.** The plastic filter bowl unscrews for easy cleaning. When removing the bowl, carefully lift it straight up and off of the threaded stud to minimize the possibility of dislodging contaminants which may be caked on the filter surface. If contaminants are found caked on the disposable filter element, it is an indication that the disposable filter element should be replaced more frequently. The bowl should be cleaned only with a solution of mild detergent and warm water. Rinse with clean tap water, and dry with a clean soft cloth. When reassembling the plastic bowl with disposable element to its base, make certain that the "O" ring which seals the bowl to the base is properly seated in the base.

## SECTION 20

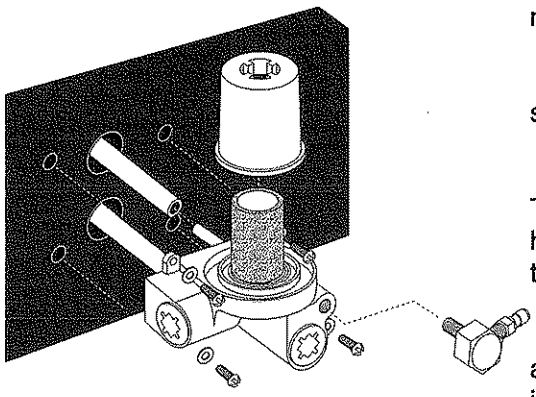


FIGURE 23:
**TRI FILTER ASSEMBLY, REMOVAL AND INSTALLATION VIEW**

**2.** The disposable filter element should be replaced monthly, or more frequently as needed to ensure the best possible performance from the analyzer. See the **REPLACEMENT PARTS** list at the end of this manual.

**3.** There are stainless steel screen filters behind both the rear and side facing filter retainers.

**4.** Carefully unscrew the filter retainers to remove the screen filters. The filter may or may not come out with its retainer. If it stays inside the housing, carefully pull it out with a needle nose plier or other suitable tool.

**5.** Note that the filter retainers are identical, but the filter screens are different. The gas filter which enters the side of the tri filter housing is approximately 1 1/8" in length, the water filter which enters the rear of the housing is approximately 1 7/16" in length. How often these filters will require cleaning is dependent upon the type of use to which the analyzer is exposed. In locations where older vehicle testing is predominant, these screens should be cleaned every other day. In locations where newer, less polluting vehicles are being tested, the screens should be cleaned after every 40th vehicle has been tested.

### TRI FILTER BODY - REPLACEMENT

Should the need arise to replace the entire tri filter assembly, follow the procedure outlined below.

**1.** Turn the analyzer **OFF**.

**2.** Remove the exhaust sample hose from the tri filter assembly.

**3.** Remove the male quick connect fitting to which the exhaust sample hose was connected. This fitting will be reused on the new tri filter assembly.

**4.** Remove the large top filter bowl from the tri filter assembly. This is necessary in order to gain access to the top right screw of those removed in step 5 below.

**5.** Remove the four (4) phillips screws which secure the tri filter assembly to the analyzer.

**6.** The tri filter can then be pulled straight out from the rear panel approximately 1 to 1-1/2 inches. (See FIGURE 23)

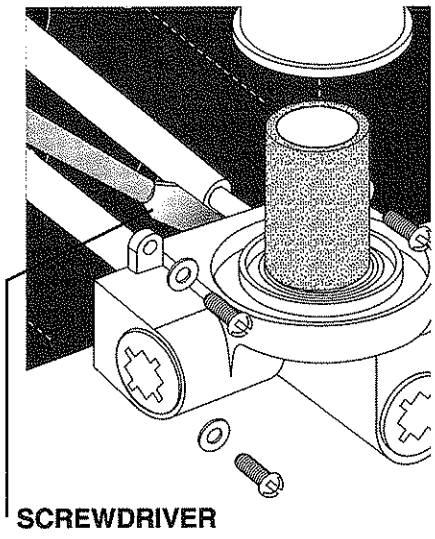



FIGURE 24:
**TRI FILTER BODY, REMOVAL AND INSTALLATION VIEW**

**CAUTION**

Do not allow the hoses to slip back inside the analyzer housing when they are removed in Step 7.

**7.** Using a large blade screwdriver, carefully pry the hoses off of the tri filter as shown in FIGURE 24.

**8.** To install the new tri filter, reverse the removal procedure.

## COOLING FAN FILTER

**CAUTION**

Do not operate the analyzer without the cooling fan filter in place.

The cooling fan filter should be checked at the same time the tri filter assembly is checked. Maintain it as indicated below.

**1.** Snap the finger guard containing the filter off of the fan as shown in FIGURE 25.

**2. CAREFULLY** blow compressed air through the filter in the direction opposite normal air flow. (Normal air flow has the fan drawing fresh air through the filter and into the analyzer). The fan finger guard and element are available as a replacement part. See the **REPLACEMENT PARTS** list at the end of this manual.

**3.** Snap the guard and filter assembly back on the fan when cleaning is complete.

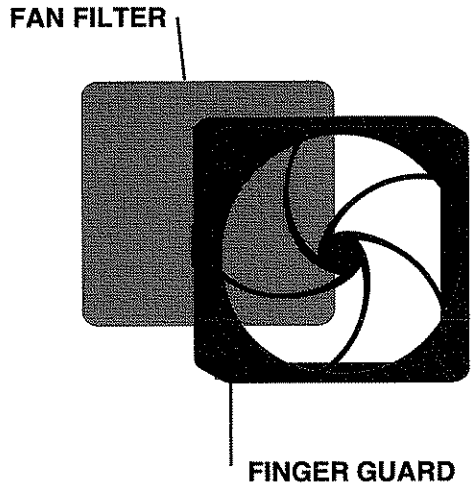



FIGURE 25:
**COOLING FAN AND FILTER ASSEMBLY**

## OXYGEN SENSOR LIFE EXPECTANCY, TEST AND REPLACEMENT PROCEDURES

The oxygen sensor works very similar to a battery in that it produces a voltage via a chemical reaction. As with any battery, it has a defined life expectancy, and this life expectancy will vary depending on the type of use and care it is given.

As with the rest of the sampling system, maximum sensor life will be achieved only if the filtering system is kept clean! If dirt accumulates on the sensing element of the oxygen sensor, it will no longer be able to detect changes in oxygen level, and will have to be replaced before it would otherwise be necessary. With proper maintenance, the following life expectancies may be anticipated:

| USAGE | LIFE EXPECTANCY (MONTHS) |
|---|---|
| Heavy | 12 - 16 |
| Light | 18 - 22 |

An analyzer which is used continually or regularly every day would be considered heavy usage.

An analyzer which is used intermittently or periodically during the week would be considered light usage.

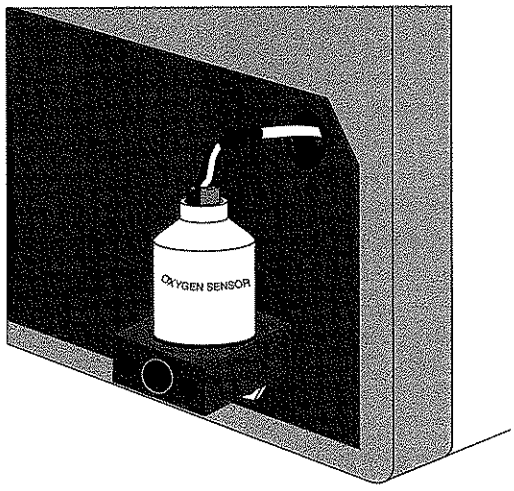



FIGURE 26:
**OXYGEN SENSOR LOCATION ( BACK RIGHT OF THE ANALYZER )**

# SECTION 20

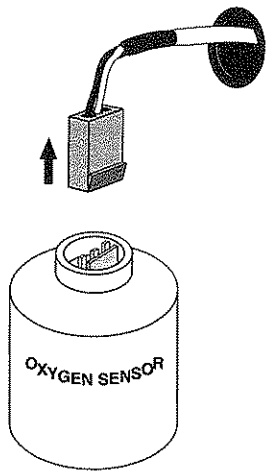



FIGURE 27:
**OXYGEN SENSOR ELECTRICAL CONNECTOR REMOVAL**

Note that the sensor will give very little warning when it is coming to the end of its useful life. It could go from full output to "dead" in as little as one (1) day.

So to avoid analyzer down time, it is recommended that a replacement sensor be purchased no more than two (2) to three (3) months prior to anticipated need. Although sensors are packaged in an air tight bag immediately following manufacture, it is impossible to completely eliminate shelf life deterioration. **Do not remove the sensor from its packaging until you are ready to install it!**

If the analyzer's $O_2$ display is not indicating approximately 21% oxygen in ambient (fresh) air after completing its automatic zero cycle, the oxygen sensor may be at fault. The following procedures will outline testing of the oxygen sensor, and its replacement if required. You will need a digital voltmeter with one (1) millivolt resolution and capable of reading ten (10) millivolts.

Test the oxygen sensor as follows:

**1.** With the analyzer in the **RUN** mode, press the **ZERO** switch and allow the analyzer to complete its automatic zeroing cycle. This will purge the sampling system of any residual exhaust gas and assure that the oxygen sensor sensing element is in zero air. Turn the analyzer **OFF**.

**2.** Gently pull the electrical connector up and off the oxygen sensor. (see FIGURE 27)

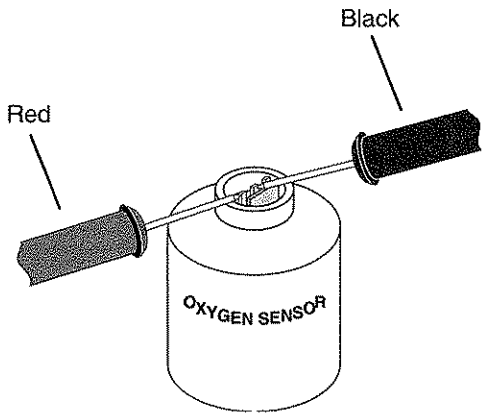



FIGURE 28:
**OXYGEN SENSOR TEST**

**3.** Set your digital voltmeter to measure D.C. millivolts. The anticipated voltage is approximately 10 millivolts.

**4.** Connect the negative (-) lead of the meter to the center pin of the electrical connector on the oxygen sensor. Connect the positive (+) lead of the meter to the **correct** outer pin of the connector as shown in FIGURE 28. Use the location of the electrical connector's locking ramp and its relationship to the pins on the oxygen sensor's connector to determine the correct test connection point for the positive (+) lead of the meter.

**5.** Observe the meter reading. A good oxygen sensor will produce a reading of between 7 and 13 millivolts. If the reading on the meter falls within this range, reinstall the electrical connector. Observe proper polarity as indicated by the mating locking ramp and latch on the cable and sensor header connector respectively. If a minimum of 7 millivolts is not produced, replace the sensor as described below.

**6.** Replace the oxygen sensor as follows:

**A.** Gently pull the electrical connector up and off the oxygen sensor if not already done.

**B.** Unscrew the oxygen sensor from its mounting block. No tools should be required.

**CAUTION**

Do not attempt to disassemble or repair the oxygen sensor, as it contains caustic material. Dispose of properly!

**C.** Remove the replacement sensor from its packaging. Make sure that the "O" ring is in place on the new sensor, and screw it onto the mounting block. Tighten the sensor until it makes contact, and then an additional 1/4 turn.

**D.** Install the sensor cable electrical connector. Observe proper polarity as indicated by the mating locking ramp and latch on the cable and sensor header connector respectively.

# TROUBLESHOOTING

## SECTION 21

### TROUBLESHOOTING GUIDE

| SYMPTOM | SUGGESTED SOLUTION |
|---|---|
| Unit will not turn on | Check fuse - if defective, replace only with the appropriate rated fuse. If the replacement fuse blows, the analyzer needs to be serviced.<br>Check power cable with ohmmeter for continuity.<br>Power switch in ON position.<br>Check outlet for 115 or 230 VAC, tripped breaker, etc. |
| Not all display segments and function LEDs are lit on initial power up | Analyzer needs to be serviced. |
| Displays will not change (frozen) | Turn analyzer OFF, wait five (5) seconds and turn back ON. Make sure that the 115 or 230 VAC supply is "electrically clean". Heavy duty equipment such as air compressors can cause line voltage drops when they start up. |
| LOW FLOW indication | Check sample hose & probe for blockage. Check tri-filter assembly and associated plumbing for cleanliness, blockages, and connection integrity. Make certain that the leak check cap is not installed. |
| In RUN mode, no suction at sample hose - no LOW FLOW indication | Remove exhaust gas sample hose from rear of analyzer. (Analyzer must be in RUN mode.) Place finger over fitting on analyzer. If suction is felt, and the LOW FLOW indicator comes on, the pump and all internal plumbing are functioning properly. Check for correct and tight hose connections, tri filter properly assembled and tight. |
| CO, $CO_2$, and HC read low, while $O_2$ remains excessively high during vehicle testing | Air leak in sample hose/filter/plumbing system which is allowing outside air in with the exhaust gas and is diluting it. Perform system LEAK CHECK. |
| HC wanders erratically in standby, (or run with sample probe in fresh air.) | It is normal for the HC display to vary from approximately -10 through 0 to +10. If the variation is greater than this, check for other sources of hydrocarbons such as spilled gasoline, oil, kerosene, etc. or shop rags still wet from any of these petroleum products. In a multi-bay shop, check for other vehicles whose engines may be running poorly or whose tailpipes are not vented to the outside. Perform the hydrocarbon hangup test. |

# REPLACEMENT PARTS LIST

## SECTION 22

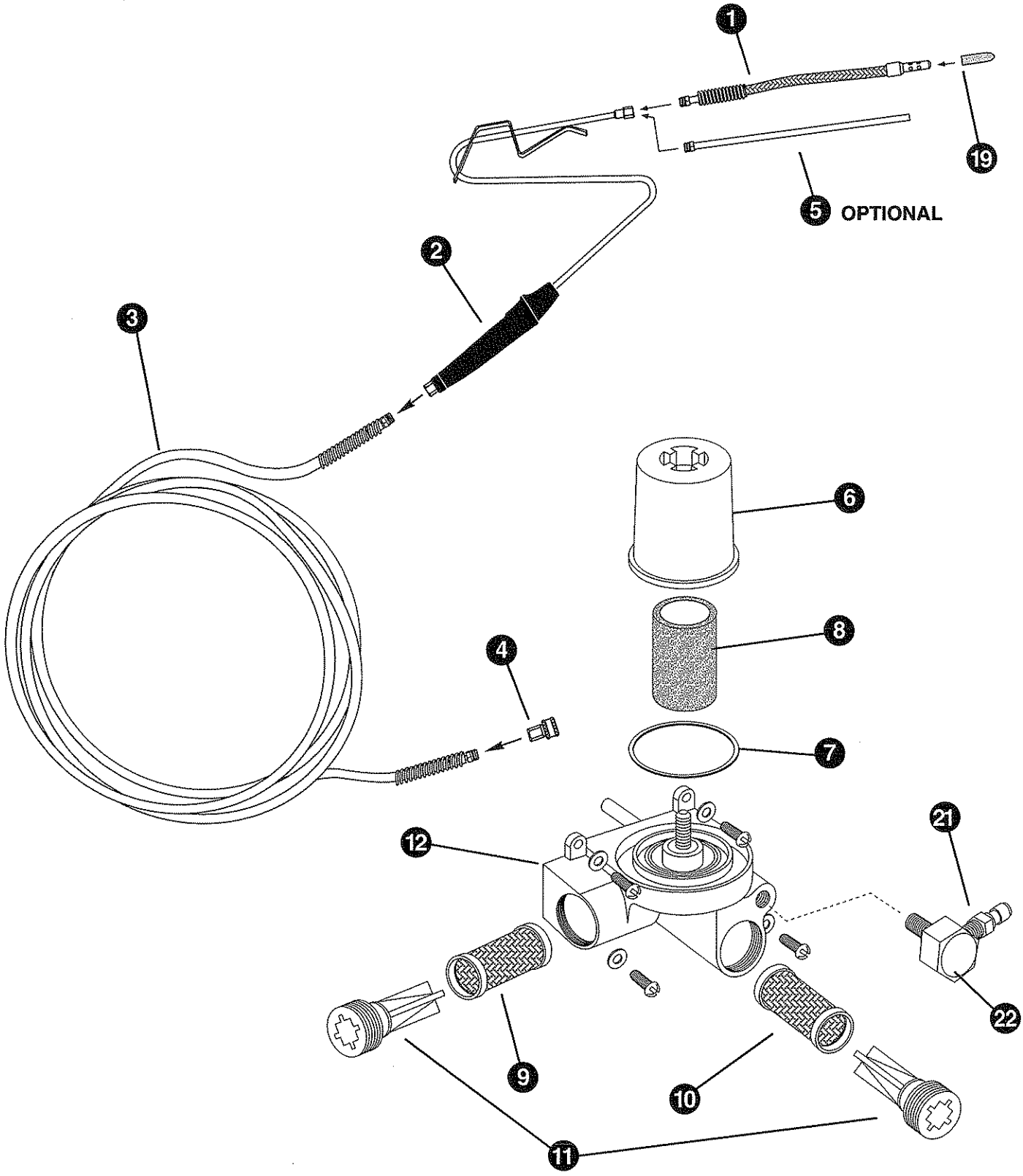
### REPLACEMENT PARTS

| KEY NO. | PART NO. | DESCRIPTION |
|---|---|---|
| 21 59.07 | 60 84920 | Exhaust Gas Sample Flexible Metal Hose |
| 2 46.53 | 60 84900 | Exhaust Gas Sample Probe Handle Assembly |
| 3 51.48 | 60 06300 | Exhaust Gas Sample Hose (25 ft) |
| 4 14.18 | 60 55710 | Quick Connect Female Hose Connector |
| 5 | 60 84910 | Exhaust Gas Sample Anti-dilution Adapter (OPTIONAL) |
| 6 | 400-1784 | Filter Bowl |
| 7 | 400-1786 | Filter Bowl Gasket |
| 8 10.62 | 400-1785 | White Filter Element |
| 9 29.70 | 400-1787 | Gas Screen Filter - Short, 1-1/8" over all length |
| 10 20.59 | 400-1788 | Water Screen Filter - Long, 1-7/16" over all length |
| 11 | 7-0082 | Filter Plug with "O" Ring |
| 12 | 7-0083 | Tri Filter Body |
| 13 | 400-1663 | Printer Paper Axle Rod |
| 14 | 400-1726 | Printer Paper (100 ft Roll) |
| 15 | 60 97237 | Oxygen Sensor |
| 16 | 180-1140 | 1/8" X 27 NPTM X 1/4" Barb Hose Brass Fitting (Cal Gas Input) |
| 17 | 400-1419 | PVC Tubing (Water Drain, Zero Air, & Exhaust Outlet) Specify number of feet reguired when ordering. |
| 18 | 38-1646 | Power Cable, 120 Volt A.C. |
| 19 2.50 | 400-1803 | Leak Check Cap |
| 20 | 400-1777 | Cooling Fan Finger Guard with Filter Element (one piece) |
| 21 | 180-913 | Quick Connect Male Fitting |
| 22 | 7-0084 | Right Angle Inlet Fittting with "O" Ring |
| 23 | 400-1748 | Printer Lens/Tear Bar |
| 24 | 450-173 | Slip-on cap, Paper Feed switch |
| 25 | 180-1148 | Thumbscrew (Paper Feed door) |
| 26 | 300-163 | "E" Ring Retainer for Thumbscrew (Paper Feed door) |
| 27 | 400-1817 | Dust Cover, Product |
| | 44-109 | Fuse, 5mm X 20mm (GMA 3 Amp 250 Volt) (Not illustrated) |
| | 44-110 | Fuse, 5mm X 20mm (GMA 1.5 Amp 250 Volt) (Not illustrated) |
| | 2-209001 | Instruction Manual (Not illustrated) |

**ILLUSTRATION OF PARTS IS SHOWN ON NEXT 2 PAGES**

# REPLACEMENT PARTS

## SECTION 22



# REPLACEMENT PARTS

## SECTION 22